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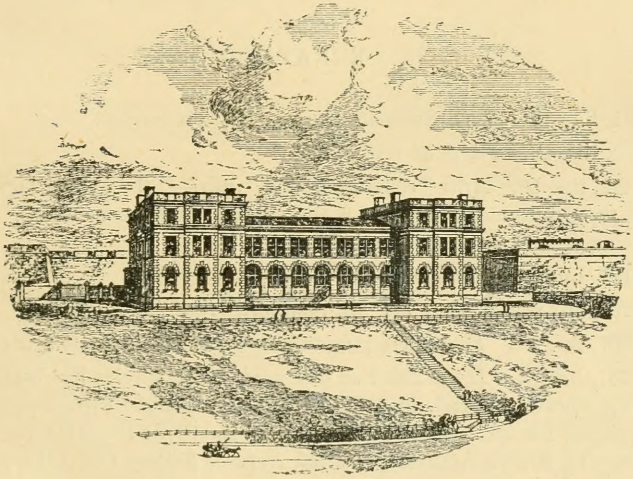
Journal

OF THE

MARINE BIOLOGICAL ASSOCIATION

OF

THE UNITED KINGDOM.



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3719

ERRATA.

P. 61, line 18. *For* Shpoerodoridae *read* Sphaerodoridae.

P. 61, line 20. *For* p. 33 *read* p. 38.

P. 122, line 30. *After* "conclusion that," *insert*—"the hybrid larvæ were of all types intermediate between the paternal and the maternal. In the following year Doncaster (5) decided that," . . .

P. 187, line 12. *For* 40,000 *read* 3000.

P. 295, last paragraph. *For* "G. Southern" *read* "R. Southern."

P. 307, line 39. *For* "these investments" *read* "thin investments."

P. 331, line 34. *Delete this line and read*, "The species has been recorded from the Shetland Islands by Jäderholm (*Kungl. Svenska Vetenskaps-akademiens Handlingar*, Bd. 45, 1909, p. 109), and from the Clyde Sea Area and the Firth of Lorne by Ritchie (*Annals of Scottish Natural History*, Oct. 1911, p. 223)."

P. 351, line 6. *For* "Phytisca" *read* "Phtisica."

P. 355, lines 23–27. *Transpose* "Brachyura" *to immediately above* "Leucosiidae."

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A. E. Hefford, B.Sc.

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THE observations which form the subject of the following notes deal with only part of the total material on which my studies of teleostean reproduction, pursued during the last two years, have been made; but as the other and larger part of the material consists of preserved specimens of the young (chiefly post-larval) stages of fishes collected during the four years 1906 to 1909 inclusive, it is more convenient to deal with the egg collections of the past year first and to treat the whole collection of young fry separately in a further paper.

Systematic examination of tow-nettings for pelagic fish-eggs began on February 11th, and in the early months before the steamer was in commission, owing to the exigencies of weather and time which attend the use of a small sailing-boat, samples were taken only inside the Sound or in its near vicinity. As will be seen from the analysis of the collections given in Table I, there was a break of more than a month's duration, beginning early in March. From April to the end of August the s.s. *Oithona* was available, which not only rendered collections from the open-sea areas possible, but also permitted the use of the Petersen young-fish trawl, by which large quantities of fish-eggs could be obtained. The quantities so obtained were generally much too large to admit of their individual examination, and therefore it was my practice to pick out a portion of the total eggs for careful examination and frequently for hatching in the laboratory, while the residue was scrutinized as carefully as possible so that the rarer specimens should not be omitted. After a certain amount of practice one can recognize many of the familiar species by size and other peculiarities even with the naked eye, so that after a confirmatory microscopic examination it is possible to obtain a fair knowledge as to the identity of the majority of the species present in a plankton sample, and then exceptional eggs can often—though not, of course, without exception—be discerned. In the case of tow-net samples, which were taken with coarse (24 strands to the inch) or medium (50 strands to the inch) nets at various depths from the surface to about 9 or 10 fathoms, care was taken to pick out every individual egg. The hauls were in most cases of 15 minutes' duration, so that quantitative comparison is to some degree possible. Throughout this work I have conducted my observations having in view practical fishery questions—e.g. the locating of spawning areas, the duration of the spawning period, and the relative extent of the breeding of various species of fishes in the Plymouth area—rather than details of purely biological interest, and therefore my records of the characters of eggs and larvae have had special regard to points for purpose of ready identification at the various stages of development; hence details of embryology have little place in this paper.

The ova and larvae of the majority of species occurring here are already more or less completely known, thanks to the labours of Cunningham, Holt, McIntosh, Masterman, etc., in this country, and to Ehrenbaum and other continental investigators, so that the main object of the descriptive notes which follow is to fill up gaps or to amplify those previous observations which still lack completeness. It is, perhaps, unnecessary to point out that records of such essential diagnostic characters as dimensions, additional to those which have been made on an extensive scale in investigations made in various parts of the North Sea and elsewhere, are of no little importance and value, owing to the local variation which occurs in such respects.

In glancing at the general constitution of my egg samples, as shown in Table I, perhaps the most striking feature is the vast preponderance of those belonging to unmarketable forms. The species which afforded the most numerous pelagic eggs was the rockling, *Onos* (*Motella*) *mustela*, and not far behind this in abundance come the gold-sinny or rock-wrasse (*Ctenolabrus rupestris*), the boar-fish (*Capros aper*), and the dragonet (*Callionymus lyra*). Doubtless more eggs of such important families as the Gadidae and Pleuronectidae would have been taken if more off-shore collections had been possible. One may assume that the relative abundance of planktonic eggs, if sufficiently numerous samples are taken, is a fairly reliable index to the proportionate numbers of mature fish occurring in the area under observation at the spawning period. It is therefore to be expected that samples of planktonic eggs from inshore areas should consist predominantly of those from the littoral species of rockling and wrasse.* The same cause, however, does not explain the predominance of dragonets, boar-fish, and Norwegian top-knot over such forms as whiting, dab, plaice, and sole, which are marketable fish of much importance to our local trawlers and line fishermen. The general aspect of the case is that species which are regular objects of the trawlers' pursuit are poorly represented in our egg samples. How far trawling itself is responsible for this condition of things is an open question, which in any case it is not in my province to attempt to answer here. But it is a noteworthy fact that the forms mentioned above are of such small size that they would to a great extent escape through the meshes of an ordinary trawl, and therefore stand the best chance of surviving on a well-fished ground. The result cannot be entirely attributed to local distribution of the mature fish, for the Norwegian top-knot has practically the same distribution here as the sole, thickback, "merry-sole," and dab, as well as approximately the same spawning period, while the same can be said regarding *Capros aper* as compared with the gurnards.

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* It should be remembered that only one species out of the four Plymouth wrasses (viz. *Ctenolabrus rupestris*) produces pelagic eggs.

In the course of my laboratory observations, a point which has struck me as interesting and worthy of further definite inquiry, is the relative vitality of the eggs of various species, as indicated by the extent to which they are affected by the conditions under which they are kept while under observation, in the course of their development in the laboratory. On several occasions I have kept ova of different species in the same vessel of sea-water in order to watch the process of development and examine the hatched-out larvae. In such cases it frequently happened that one species would do well and produce healthy and vigorous larvae, while another would fare badly, and, if the embyro survived so long as to hatch out, the resulting larva would be more or less moribund from the outset and frequently crooked in shape. Notable among those whose vitality in the laboratory was considerable were the eggs and larvae of *Motella mustela*, *Callionymus lyra*, and *Ctenolabrus rupestris*, while those which most often appeared to be adversely affected were *Gadus*, *Trigla*, and especially the rare forms *Raniceps raninus* and *Serranus cabrilla*. It is to be expected that natural selection has effected that inshore—and sometimes even estuarine—forms like *Motella mustela* and *Ctenolabrus rupestris* should produce eggs which are capable of a wider range of environmental change (e.g. of temperature, to take the most obvious factor which operated in the cases under discussion) than those species which spawn in deeper water, where the surrounding conditions are of a more uniform character. In the case of *Serranus cabrilla* it is not surprising that ova produced in this neighbourhood, which must be at the extreme limit of the natural spawning area of this species, should be of less than average health. The laboratory temperature falls below that of the sea at times in winter, and in summer is generally above it. In the hot weather my vessels containing eggs were put to stand in running aquarium water for the sake of coolness. The same should be done if frost is to be feared in winter. I kept my eggs in sea-water obtained from well outside the Sound, or in aquarium water which had been treated with animal charcoal and then filtered through a "Berkefeld" filter.*

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* See Allen and Nelson, "On the Artificial Culture of Marine Plankton Organisms," *Journ. M.B.A.*, Vol. VIII, No. 5, p. 432.

TABLE I.—SHOWING NUMBER AND PARTICULARS OF CAPTURE OF PELAGIC FISH-EGGS TAKEN OFF PLYMOUTH IN SPRING AND SUMMER, 1909.

No. of Sample.	Date.	LOCALITY.	Gear.	Duration of haul (minutes).	Depth (fathoms).	Ctenolabrus rupestris.	Capros aper.	Trachinus vipera.	Callionymus lyra.	Solea vulgaris.	S. variegata.	Pleuronectes flesus.	P. microcephalus.	Zeugopterus norvegicus.	Gadus merlangus.	G. minutus.	G. luscus.	Onos mustela	C sprattus.	C. pilchardus.	Other Eggs.
1	11–II	West Channel	m	20	?	–	–	–	1	–	–	–	–	–	–	–	–	11	–	–	Gadus sp. (3).
2	17 ,,	,, ,, ...	m	15	ca. 3	–	–	–	3	–	–	–	–	–	–	–	–	5	2	–	Gadus sp. (1).
3	,, ,,	,, ,, ...	c	15	ca. 1½	–	–	–	–	–	–	1	–	–	–	–	1	4	8	–	Zeugopterus punctatus (1), Gadus sp. (1).
4	20 ,,	Between Shagstone and Breakwater	m	15	1	–	–	–	1	–	–	1	–	–	–	–	1	ca. 50	1	–	
5	,, ,,	,, ,, ,,	c	15	3	–	–	–	–	1	–	–	–	–	–	–	–	9	1	–	Z. punctatus (1), Gadus sp. (1).
6	25 ,,	West Channel...	m	15	3½	–	–	–	1	–	–	–	–	–	1	–	–	21	1	–	Z. punctatus (3), Gadus ? luscus (3)
7	4–III	,, ,, ...	m	15	?	–	–	–	>1	–	–	3	–	–	–	–	–	>3	>6	–	Z. punctatus (3).
8	,, ,,	,, ,, ...	c	15	?	–	–	–	2	–	–	2	–	–	–	–	–	sev.	ca. 10	–	Z. punctatus (1).
9	8 IV	7 miles S.W. of Eddystone	m	15	—	–	–	–	7	–	2	–	1	–	–	–	–	–	7	9	G. ? luscus (3), G. ? minutus (1).
10	,, ,,	,, ,, ,, ...	c	15	—	–	–	–	3	–	6	–	1	–	–	–	2	–	ca. 10	sev.	Gadus sp. (1), G. ? minutus (1).
11	19 ,,	Between Mewstone and Breakwater...	m	15	3	–	–	–	6	–	–	–	–	4	–	–	–	1	–	–	
12	,, ,,	,, ,, ,, ...	c	15	ca. 7	–	–	–	2	–	–	–	1	3	–	–	–	2	–	–	Z. punctatus (1).
13	20 ,,	Off Cawsand Bay	c	15	ca. 9	–	–	–	1	–	–	–	–	6	–	–	1	8	1	–	Z. ? punctatus (1).
14	23 ,,	West Channel...	c	15	ca. 4	–	–	–	–	–	–	–	–	–	–	1	–	9	–	–	Z. ? punctatus (1), Zeugopterus sp. (1).
15	28 ,,	Cawsand Bay	t	15	—	–	–	–	10	–	–	–	1	–	1	–	–	–	4	–	Zeugopterus sp. (2).
16	3 V	Off Ram's Cliff	t	15	—	–	–	–	–	1	3	–	–	–	–	–	–	3	1	–	Z. punctatus (5), Gadus ? minutus (1).
17	7 ,,	Jennycliff Bay	t	15	—	? 1	–	–	2	–	–	–	–	2	–	–	–	3	3	–	Unidentified (1).
18	11 ,,	Cawsand Bay	t	15	—	4	–	–	2	–	–	–	1	1	–	–	–	17	4	–	
19	12 ,,	Off Ram's Cliff	t	15	—	1	–	–	1	–	–	–	–	1	–	–	–	2	–	–	Z. punctatus (1).
20	18 ,,	Yealm Point, N.N.E., 1½ miles ...	c	10	4	4	–	–	–	–	–	–	–	3	–	–	–	–	–	–	
21	21 ,,	Eddystone Ground	c	15	7–10	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	
22	24 ,,	Whitsand Bay	t	15	—	5	–	2	1	–	–	–	2	1	–	–	–	3	12	–	Z. punctatus (1).
23	2–VI	Rame Head, N., 2 miles	t	15	—	11	–	–	–	–	–	–	–	1	–	–	–	–	–	–	Onos sp. (1).
24	11 ,,	Whitsand Bay	t	15	—	sev.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	

No. of Sample.	Date.	LOCALITY.	Gear.	Duration of haul (minutes).	Depth (fathoms).	Ctenolabrus rupestris.	Capros aper.	Trachinus vipera.	Callionymus lyra.	Solea vulgaris.	S. variegata.	Pleuronectes flesus.	P. microcephalus.	Zeugopterus norvegicus.	Gadus merlangus.	G. minutus.	G. luscus.	Onos mustela.	C. sprattus.	C. pilchardus.	Other Eggs.
25	14–VI	Rame Head, N. by E., 2 miles ...	c	15	ca. 4	3	2	1	2	–	–	–	–	3	–	–	–	–	2	–	
26	21 ,,	West Channel...	c	10	ca. 4	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
27	21 ,,	,, ,, ...	c	?10	0	6	–	1	–	–	–	–	–	–	–	–	–	–	3	–	
28	22 ,,	Cawsand Bay	c	10	0	14	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
29	,, ,,	,, ,, ...	t	10	—	m	–	4	1	1	–	–	–	–	–	1	–	–	–	–	
30	25 ,,	,, ,, ...	t	20	—	v.m.	–	2*	1*	–	–	–	–	–	–	–	–	3*	v.m.	–	
31	28 ,,	Rame Head, N. by E., 3 miles ...	c	?	—	3	5	–	–	–	–	–	–	6	–	–	–	–	1	–	Onos ? tricirratus (1).
32	,, ,,	,, ,, ,, ...	c	15	3½	4	–	1	–	–	–	–	–	–	–	–	–	–	1	–	
33	29 ,,	Eddystone, N.W. by W., 1 mile ...	t	15	—	–	v.m.	–	1	–	–	–	–	–	–	–	–	–	–	–	Caranx trachurus (1).
34	,, ,,	,, ,, ,, ...	t	15	—	–	–	sev.	–	–	1	–	–	–	–	–	–	–	–	–	
35	2-VII	Eddystone, S. by E., 1¼ miles ...	c	12	0	4	v.m.	–	–	–	–	–	–	–	–	–	–	–	–	–	? Raniceps raninus (1).
36	,, ,,	,, ,, ,, ...	c	12	4	3	18	–	–	–	–	–	–	–	–	–	–	–	–	–	Solea lutea (1).
37	5 ,,	Eddystone, S.E., 2¾ miles	c	10	0	1	11	–	–	–	–	–	–	–	–	–	–	–	–	–	Trigla sp. (1).
38	,, ,,	,, ,, ,, ...	c	10	3	–	1	–	–	–	–	–	–	–	–	–	–	–	–	–	
39	8 ,,	Just outside Breakwater	t	10	—	–	–	sev.	1	–	–	–	–	–	–	–	–	–	m	–	Trigla sp. (1).
40	12 ,,	,, ,, ...	c	12	2	5	1	–	–	–	–	–	–	–	–	–	–	–	–	–	
41	,, ,,	,, ,, ...	c	10	0	8	3	–	–	–	–	–	–	–	1	–	–	–	2	–	Trigla sp. (1).
42	20 ,,	Eddystone, N.W., 1½ miles... ...	c	15	0	sev.	m	–	–	–	–	–	–	–	–	–	–	–	–	–	
43	,, ,,	,, ,, ,, ...	c	15	2	–	sev.	–	–	–	–	–	–	–	–	–	–	–	–	–	
44	26–VIII	Eddystone, S.W., 1½ miles	t	15	—	–	4	–	–	–	–	–	–	–	–	?1	–	–	–	–	
45	,, ,,	,, ,, ,, ...	t	15	—	–	1	1	–	–	3	–	–	–	–	?1	–	–	–	1	? Rhombus laevis (1).
46	27 ,,	Rame Head, E.N.E., 3 miles ...	t	15	—	–	4	1	–	–	–	–	–	–	–	?6	–	3	–	–	Serranus cabrilla (4). [ratus (1).
47	30 ,,	Rame Head, S.E. by E., 1 mile ...	t	15	—	–	–	–	3	–	–	–	–	–	–	–	–	–	–	–	Raniceps raninus (4), O. ? tricir-
48	14–IX	West Channel and inside Breakwater	c	?15	>3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	
49	,, ,,	,, ,, ,,	c	15	ca. 3	–	–	–	–	–	–	–	–	–	–	–	–	10	–	3	

Symbols used :—Under "Gear," m = medium tow-net, c = coarse tow-net, t = young-fish trawl.

In numbers columns, sev. = several, m = many, v.m. = very many.

* This number only observed. Probably more present in catch.

I. PELAGIC EGGS.

Ctenolabrus rupestris, L. Gold-sinny or Rock-wrasse.

Holt (**11a**), p. 465, Figs. 23, 24, 28–30.
Heincke u. Ehrenbaum (**10**), p. 266, Fig.17a–d.

This species afforded the most numerous of the pelagic eggs taken during the months of May, June, and July. Belonging to a littoral species it was taken for the most part in near-shore tow-nettings, and was practically absent from the offshore Eddystone Grounds; but there was one notable exception to this on July 20th, when several were taken one and a half miles south-east of the Eddystone. The egg, which is easily recognized by its small size, clear homogeneous yolk devoid of an oil-globule, small perivitelline space, and embryo with slender body and uniformly distributed pigment, has been described by Holt (*op. cit.*) from the south-west coast of Ireland and from the Gulf of Marseilles, and by Heincke and Ehrenbaum from Heligoland. The size of the egg is liable to much variation. The diameters recorded for the North Sea are 0·72 to 0·94 mm., for the Mediterranean 0·70 to 0·83 mm., and for the Irish coast 0·835 mm. The diameter of my eggs ranged from 0·78 to 0·90 mm., averaging ·878 in May, ·839 in June, and ·822 in July. The first specimen was taken on the 7th of May, the last on the 20th of July. The newly hatched larva has a total length of 2·16 mm., the distance from snout to anus being 1·22 mm.

The post-larval stages have been taken in the young-fish trawl from late June onward, but they do not appear in that relative abundance which one might expect from the commonness of the ova. This is probably due to the fact that they early seek the environment of inshore rocks, which is the habitat of the adult. Holt (**11d**, p. 125) speaks of young examples being common on the zostera beds of Cawsand Bay and the Yealm estuary, but judging from his later publication of a drawing of a young wrasse taken at Fowey (Marseilles, 1899), and erroneously identified as *C. rupestris*, it is probable that at this time he was confusing this species with another wrasse, probably *L. maculatus*, the young of which are more commonly met with off the shores of this neighbourhood in summer. The later post-larval stages, like the early larva, are characterized by their lack of black pigment, which is limited to a large spot at the base of the posterior end of the anal fin and at the base of the caudal fin, and for the rest a little in the peritoneum, on the head and on the throat.

Serranus cabrilla, L. The Gaper.

Raffaele (**20**), p. 19, Tav. I, Fig. 5, Tav. II, Figs. 1 and 3.
Holt (**11f**), p. 11, Pl. IV, Figs. 33–40.

Four eggs with homogeneous yolk and single oil-globule were taken on August 27th and six on August 30th, in each case in plankton caught by the young-fish trawl in Whitsand Bay. In both cases the eggs soon developed unhealthy symptoms, and the characters of the embryo and larva must be considered with this condition borne in mind. The diameter of the eggs ranged from 0·92 mm. to 0·97 mm. and the size of the oil-globule from 0·14 to 0·15 mm. Before the formation of the embryo the surface of the yolk presents a roughened appearance, which may be due to a slight granulation in the periblastic region (cf. Holt, *op. cit.*, p. 12). Just before the outgrowth of the free caudal region a few round, pale yellow chromatophores have appeared along the sides of the embyro, and smaller, somewhat inconspicuous dark stellate chromatophores are fairly uniformly distributed all over the body. As development proceeds the pigment spots increase in size, single yellow chromatophores by the anus and in the mid-post-anal region being well marked. There is a little pigment of each colour over the oil-globule, but none on the yolk-sac. The hatched-out larvae were moribund in every case. The length of the newly hatched larvae (Fig. 13) varied from 1·84 to 2·30 mm. The largest and most whole specimen measured 1·00 mm. from the snout to the posterior edge of the yolk-sac, and 1·26 mm. from snout to anus. The post anal length of 1·04 mm. should have a trifle added to it to allow for the slight shrinkage which had taken place. The pigment has a very characteristic distribution, but varies somewhat in the size and number of the chromatophores. Black pigment is confined to the dorsal (anteriorly it may be dorso-lateral) region of the head and trunk, extending as a dorsal line to the caudal extremity. The yellow, which by transmitted light shows a greenish tint, is confined on the body itself to a few rather widely separated chromatophores of large size. In an average case there are one on the head; one behind the otic region; two in the pre-anal dorsal line; two lateral spots at the level of the posterior edge of the yolk-sac; one very large one over the anus and at the mid-post-anal point in the dorsal and ventral contours. Ramifications extend into the unpaired fins in the two latter cases. All the larvae observed showed one large dorsal mid-post-anal chromatophore, but the corresponding ventral pigment may consist of as many as four chromatophores. In the dorsal fin there is a row of four to six large chromatophores, which usually exhibit upwardly and outwardly radiating outgrowths. The most posterior of the series is a little behind the dorsal chromatophore of the caudal region. There may be corresponding pigmentation in the anal fin, but it is not so extensive, from two to four chromatophores being the usual occurrence. The pre-anal fin may have a spot of yellow pigment near its margin, and invariably there is a small patch in its antero-dorsal angle, where the contours of yolk-sac and intestine converge. There is no pigment on the yolk-sac, but over the oil-globule there are one or two chromatophores of each colour.

Normally the yolk-sac is somewhat elongated and bears the oil-globule at its anterior end, but the position of the oil-globule shows some variation, and in two cases was only just within the anterior hemisphere.

The general form of the larva resembles that of Holt's Fig. 33 (*op. cit.*), the characteristic features apart from pigmentation being the ovoid yolk-sac with anteriorly placed oil-globule and the broad pre-anal fin membrane.

My late embryos and larvae all showed a marked tuberculated epidermis, which was doubtless a pathological condition, and may be regarded as diagnostically unimportant.

On referring to previous observations by Raffaele and Holt of Mediterranean species, one finds conspicuous characteristic features which are common to all the above and to my Channel specimens, but there are also puzzling variations which, in the case of the Gulf of Marseilles specimens, do not seem to be altogether explicable as being the result of partial observations of more than one species. Raffaele (*op. cit.*, p. 19) deals with the eggs of three species, which I give below with the dimensions :—

	Diam. of egg. mm.	Diam. of oil-globule.
Serranus (*Centropristis*) *hepatus* . .	0·78	0.145
S. cabrilla	0·90	0·15
S. scriba	0·90	0·122

He figures the larvae of *S. scriba* and *S. cabrilla* (Tav. 2, Figs. 1–4), but does not give larval dimensions nor any further indication as to the specific pigmentation than can be derived from the uncoloured drawings.

In size my eggs agree most with his *S. cabrilla*, although slightly larger. Raffaele's newly hatched *S. cabrilla* larva has the oil-globule centrally situated, while his *S. hepatus* shows it anteriorly situated. The former has large mid-post-anal dorsal and ventral chromatophores.

In the unpaired fins of the newly hatched larva there is no pigment, but a four to five days' old larva shows two large chromatophores on the dorsal and anal fins.

Holt (*op. cit.*, p. 11) examined several Serranoid eggs from the Gulf of Marseilles and found among them unusual variability. The diameter varied from 0·72 to 0·89 mm. (for the most part lying between 0·78 and 0·84 mm.), and the oil-globule from 0·14 to 0·16 mm. He found that the embryonic pigment, which first appeared before the outgrowth of the caudal rudiment (the black generally, but not always, preceding the yellow), showed considerable variation, while there appeared to be no constant relation between the variations. As to the nature of the yellow pigment (often greenish yellow by transmitted light, and very pale by reflected light) Holt's records (as well as Raffaele's) agree with my observations. Both black and yellow chromatophores are shown as a rule over the oil-globule, but never over the rest of the yolk-sac. In all Holt's observations of the newly hatched larvae the oil-globule was anterior, the pre-anal part of the body slightly longer than the post-anal, the multicolumnar notochord had its vacuoles arranged fairly regularly in two series, dorsal and ventral. Pigment was disposed along the whole length of the dorsum, and was sometimes present on the sides and intestinal region. The yellow chromatophores followed the contour of the dorsum, and post-anally there were only two spots, a dorsal and a ventral, generally well defined, marking the centre of the post-anal region. The pigment on the head varied. There was always a spot at the angle formed by the intestine and the dorso-posterior profile of the yolk-sac, and also in the region of the urocyst, and sometimes others over the intestine. It is to be noted that Holt never observed any pigment in the embryonic fins of the newly hatched larva, but after three days *black* pigment appears in the embryonic fin—a row of chromatophores in the dorsal and one chromatophore in the anal fin, while black pigment, which increases with the growth of the larva, appears along the dorsal contour of the intestine (*op. cit.*, Figs. 36 and 37). My larva, on the other hand, shows *soon after hatching* a row of *yellow* chromatophores in the dorsal fin. Otherwise it agrees with the youngest larval stages which Holt represents in Figs. 33, 34, and 35, and refers to *Serranus* (*hepatus?*). It is possible that the early appearance of yellow pigment in the dorsal fin is a characteristic of *S. cabrilla*, which distinguishes it from *S. hepatus*, the species probably observed by Holt. However, a still later stage observed by him ("alévin âgé de quelques jours"), of apparently the same species, does show large yellow chromatophores associated with the relatively diminutive black ones in the embryonic fins, and also differs from the other larvae in having the black pigment of the body predominantly ventral instead of dorsal. A still further distinct variation is shown in an older stage with the yolk almost absorbed and the mouth open (but only 2·06 mm. long), which has much yellow and no black in the embryonic fin (*op. cit.*, Fig. 40).

With the material at his disposal and the small assistance derived from Raffaele's incomplete observations, Holt was unable to come to any definite interpretation of these unusual and irregular variations of larval pigment; and the still further difference displayed by my larvae does not add light to the problem. Holt referred them, or at least some of them, to *S. hepatus* as the most probable parent, on account of their smaller size as compared with Raffaele's, and because of the greater abundance of this species in the area from which his eggs were taken. He also admits the possibility of some *S. cabrilla* eggs being present among his specimens.

As to the specific identity of my eggs I have little doubt in ascribing them to *S. cabrilla*, which is a constant, though not common, inhabitant of Channel waters. As far as can be judged from Raffaele's incomplete records, the egg and larva agree with his *S. cabrilla* from the Bay of Naples, except that his figures show no pigment in the embryonic fin of the newly hatched larva, but only at a later stage. The dimensions of the egg and oil-globule show practical agreement. The date of the occurrence of the eggs agrees with Day's record of the spawning season of *S. cabrilla*. The only other member of the genus known to British waters is *S. gigas*, Cuv. and Val, mentioned by Day as an occasional and accidental visitor, who also states that "in warmer climates it deposits its ova in shallow water." I do not know of any description of the ova of this species. It does not seem likely, however, that it would spawn successfully here.

Caranx trachurus, L. Scad or Horse Mackerel.

HOLT* (11b), p. 9; (11d), pp. 116–20 and 340.
(11f), pp. 27–31, Figs. 53–63.
CANU (3b), pp. 63–71. Pl. V, Figs. 1–6.
HEINCKE and EHRENBAUM (10), p. 277, Figs. 28–31.
EHRENBAUM (5c), p. 234.

Although this species was exceedingly common off the coast in the early summer months only one egg was taken. This occurred in the catch of the young-fish trawl taken near the Eddystone on 29th June. It was not closely observed till the following day, when the larva had

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* See also North Sea Investigations, VI. "The Reproduction of *Caranx trachurus*," *Journ. M.B.A.*, Vol. III, N.S., pp. 190–4 (1893–5).

hatched out, but in an unhealthy condition and with the tail much bent. It was recognized by the larval pigmentation and by the totally segmented yolk, which bore anteriorly an oil-globule of 0·24 mm. diameter. The black and yellow pigment had a similar distribution to that in Holt's and Ehrenbaum's figures, but was not so strongly marked. On account of the deformity of the tail it was impossible to ascertain the total length. It measured 0·98 mm. to the posterior contour of the yolk-sac. Post-larval stages have occasionally appeared in the catches of the young-fish trawl in July and August. It would appear, therefore, that the fish spawns out in deep water, the drift of the eggs and larvae towards the coast requiring some little time. It will be noticed that my solitary egg was at the last stage of embryonic development when taken. Its unhealthiness also is in keeping with the general rule that the more the habitat of the species lies in the open sea the greater the difficulty experienced in rearing the larva in the laboratory. In spite of the abundance of scad at this time in these waters, all those I was able to examine were immature, so that I inferred that the older and spawning fishes did not approach the coasts so closely. Against this, however, it must be stated that as the result of his investigations in the North Sea, Ehrenbaum (*op. cit.*, p. 235) finds that *Caranx trachurus* favours as spawning places the shallow coastal areas from 10 to 25 m. depth, while outside the 30 m. line only few eggs were found.

Previous records of the occurrence of this egg in the Plymouth neighbourhood are confined to the observations of Holt (**11**d, p. 116), who obtained four specimens in July, 1897. The diameter of the egg was 0·81 to 0·93, and the oil-globule 0·22 to 0·23 mm.

Capros aper, Lacep. Boar-fish or Cuckoo.

The pelagic eggs of this species first appeared in tow-nettings taken on 14th June, and from the end of that month to the end of August our samples from the deeper water contained a well-marked preponderance of these eggs, which were especially numerous at the beginning of July in the neighbourhood of the Eddystone. The embryonic characters were first described by Cunningham (**4**a, p. 10), who artificially fertilized ova in August, 1897, and Holt has published descriptions and drawings of the larval stages (**11**f, p. 26, Pl. V, Figs. 43–8). Pelagic eggs taken by him varied from 0·93 to 1·01 mm. in diameter (chiefly ·97 to ·99), and contained an oil-globule of 0·15 to 0·165 mm. diameter. The average dimensions of my ova were:—diameter of egg, 0·946 mm.; diameter of oil-globule, 0·156 mm.; and the range of size was from 0·90 to 0·98 mm. for egg, and from 0·145 to

0·17 mm. for oil-globule, which was frequently of a yellowish tint. The species may be readily recognized towards the end of embryonic development by the characteristic yellow and black pigmentation. The yolk is homogeneous, the oil-globule of a yellowish tint, and the capsule marked with fine corrugations. At about the time of the outgrowth of the caudal rudiment black chromatophores appear on the head and in a line on either side of the body. A rather large Küpfer's vesicle is visible at this stage. Yellow pigment appears soon afterwards. One larva soon after hatching measured 1·40 mm. from snout to anus, and about 2·46 mm. in total length. Another had a total length of 2·02 mm., the distance from snout to end of yolk-sac being 1·08 mm. Black and yellow pigment occurs in rather large, stellate or dendritic chromatophores on the head and along the sides of the body. At about the level of the anus and in the mid-post-anal region there is a tendency for it to be more concentrated. The embryonic fins and the posterior extremity of the trunk are unpigmented.

In spite of the abundance of pelagic ova not a single larval or post-larval specimen occurred in our young-fish trawl collections. The young fish appear to seek early the deeper parts of the Channel. The only specimen recorded up to the present is one of 15¼ mm. length, taken in September, 1906, by the Danish research steamer *Thor*, to the west of the Channel Islands (**21**d, p. 5).

Trachinus vipera, Cuv.

This conspicuous and very easily identified egg occurred frequently though not abundantly in our samples from the latter part of May to the end of August. The many bright yellowish-green oil-globules and the richly pigmented embryo and yolk-sac render it a conspicuous object in the tow-nettings. The diameter lay between 1·28 mm. (in May and June) and 1·1 mm. at the end of August. Post-larval stages were frequently taken from the end of June throughout the summer.

TRIGLA. The Gurnards.

There are five species of Trigla occurring in the waters off Plymouth, and the specific identification of their pelagic eggs, which are similar in character and show considerable overlapping in dimensions, is a matter of great difficulty and often an impossibility. The only circumstances which ensure certainty of determination are when the spawning fish are captured in quantity at about the same time and in the same area as the eggs, so that an extensive comparison can be made between the planktonic eggs and those taken from the ripe fish.

Such, for example, were the conditions under which Holt (**11b**, p. 31) was enabled to identify the eggs of *T. cuculus* taken in April and May off the west coast of Ireland, and similarly Ehrenbaum (**5c**, p. 248) has made extensive measurements of planktonic and artificially fertilized ova of *T. gurnardus* in the North Sea, the main purpose in the latter case being to distinguish between grey gurnard eggs and those of the mackerel, which may to a certain extent coincide in diameter and size of oil-globule.

The following table shows the dimensions of artificially fertilized Trigla ova from four species which have previously been described by various observers:—

Species.	Observer and locality.	Month.	Diameter.	Size of oil-globule.
T. gurnardus	Cunningham (Plymouth)	April–May	1·45	0·30
,,	Holt (west coast of Ireland)	—	1·43–1·55	0·28–0·33
,,	Ehrenbaum (Helgoland)	June	1·256–1·258	0·25
,,	,, ,,	July	1·163–1·446	0·25
T. hirundo	Canu (Boulogne)	May–July	1·5–1·7	0·27–0·29
,,	Ehrenbaum (Helgoland)	July	1·193	0·24
,,	,, ,,	August	1·1–1·352	0·22
T. cuculus	Cunningham (Plymouth)	April–May	1·45	0·30
,,	Holt (west coast of Ireland)	May	1·47–1·61	0·28–0·33
T. lineata	Holt (Plymouth)	July	1·29–1·33	0·24

Besides the above four species, *Trigla lyra*, L., commonly known as the Piper, occurs off Plymouth in appreciable quantities, but its ova have never been described. A further difficulty is introduced by the great variation which is shown by the eggs of the same species observed in different regions and at different times. In spite of this, however, Canu (**3b**, p. 72) has stated that, as regards the eastern part of the Channel, the eggs of *T. hirundo* exceed in diameter those of all other members of the genus, but he does not give any actual observations to support this statement.

Out of my own collection, during the summer of 1909, I can only refer three eggs with absolute certainty to the Trigla genus. As to their specific identity I can say nothing, except that *T. lineata* appeared to be the most common species off Plymouth at the time (July) and may possibly have been the parent fish. There are few descriptions of gurnard eggs and larvae on record at present, so it may serve a useful purpose for future comparison if I briefly give here my own observations. On the 5th of July an egg was taken about 2¾ miles north-west of the Eddystone. Its diameter was 1·4 mm., and it contained an oil-globule of 0·22 mm. Observed on the same day, the blastodisc had almost half enveloped the yolk. Next day the embryo had formed;

the myotomes were very distinct, and faint dark pigment was just appearing. Less than twenty-four hours after this a short caudal rudiment had appeared, and the body was beset with both black and yellow pigment cells. In the caudal region yellow predominated, covering the dorsal surface almost entirely, while of black there were only a few round chromatophores. Over the yolk-sac there were many black and yellow chromatophores stellate and cruciform in shape, and the pellicle of the oil-globule was covered with large black dendritic chromatophores, each with many ramifying rays. The rudimentary pectoral fins occurred as relatively large flap-like outgrowths. On the fourth day, when the embryo had wholly surrounded the yolk, yellow pigment had increased in intensity, especially in the post-anal part, and had appeared on the pectoral fins. Black dendritic and pectinate pigment patches, together with yellow pigment, were visible on the embryonic fin membrane. The otocysts were relatively small, and situated so that the distance from the posterior edge of the eye to the posterior edge of the otocyst was equal to the diameter of the eye. The oil-globule had shrunk to a diameter of 0·20 mm. The egg died before hatching.

On the 8th July another egg of 1·28 mm. diameter and oil-globule 0·215 mm. was taken a short distance south of the Breakwater. The embryonic character as to pigmentation, etc., was quite similar to the above-mentioned, and fortunately this proved to be more healthy. On the 12th the larva was found to have hatched out and was then probably over twenty-four hours old, the yolk being partially absorbed. Its length was 4·5 mm., the distance from snout to anus being 1·7 mm. At this stage it has a general resemblance to a Zeugopterus larva, but the body is less elongate, the anus relatively nearer to the yolk-sac, and the well-developed and richly pigmented pectoral fins especially characterize it as Trigla. There is no well-defined "snout" and the frontal region is peculiarly square. The bean-shaped otocysts, with two very small otoliths, are placed immediately behind the eye. The oil-globule is situated at the posterior end of the yolk-sac, between which and the anus there is a short but deep pre-anal fin. The rectum lies at right angles to the longitudinal axis. Dorsal to the gut above the middle of the yolk-sac is a conspicuous spherical swim-bladder. The pigment is bright canary-yellow and black. The whole of the head, except the eyes, is diffusely covered with yellow. In the eye black is beginning to appear. A continuous dorsal series of rather diffuse yellow chromatophores runs back from the head to a point about 1·1 mm. from the posterior extremity, beyond which both marginal fins and body are quite unpigmented. A similar but less intense line runs along the ventral contour of the trunk. Over the surface of gut and yolk-sac is a diffuse covering of pale yellow and faint dendritic black markings. The pectoral fins are intensely yellow, with black etching-like markings round the margin in radial arrangement. On the unpaired fins there are large dendritic black and yellow chromatophores, distally distributed for the most part. In the anal fin all the pigment is marginal, while in both dorsal and anal there are fine, black, pectinate markings along the edge of the fin, similar to what is seen in *Zeugopterus norvegicus.*

A third Trigla egg of 1·34 mm. diameter was taken on 12th July, 1½ miles south of Rame Head. The embryo had formed, but the oil was still in two globules of 0·23 and 0·13 mm. diameter, which joined to make a single globule next day. On the fourth day the larva hatched out. Its total length is now 4·45 mm., the pre-anal length being 1·75 mm. In general form and pigmentation it resembles the larva above described, which was observed at a somewhat older stage. It differs slightly from that, however, in having less black pigment in the dorsal and anal fins, nor is the marginal pigment of the pectoral fin as strongly marked. Next day its length has increased to 4·74 mm. and the yolk is almost absorbed. The pectoral fins are much larger and now show the marginal fringe of black very plainly. The mouth has become distinctly enlarged and already has the characteristic gurnard form. Two days later, on the 19th, the larva, with but a very small amount of yolk left unabsorbed, has lost the brilliant yellow colouring of the younger stages. It is still fairly well marked, although diffuse, over the dorsal surface of the head and trunk, but less distinct over operculum, along the sides of the pre-anal part of the trunk and on the pectoral fins. In the unpaired fins the marginal pigment is much reduced. Black pigment has increased, especially on the pectoral fins, which it now covers from margin to basal part, but the marginal fringe is still the most dense. Dendritic chromatophores occur at intervals along the margin of the dorsal fin, but are very sparse on the anal fin except in the hypural area, where there is a rich supply arising at the ventral edge of the tail and ramifying over the fin membrane. On the corresponding dorsal side there is a faint indication of the same thing. Fine dendritic chromatophores occur on the body, being most concentrated along the dorsal contour of the gut and along the ventrolateral part of the post-anal region. Large otocysts containing relatively small otoliths are situated immediately behind the eyes. The large fan-shaped and heavily pigmented pectoral fins, and the head which is conspicuous from its well-developed jaws and operculum, give this larva a very characteristic appearance.

Callionymus lyra. Dragonet.

Although most abundant in the months of March and April and of rare occurrence during the summer, the presence of these eggs in the plankton has been recorded from 11th February to 30th August, the first and last occasion of the year on which searches for fish-ova were definitely made. The diameter of the egg varied from 0·70 to 0·91 mm., the average for February to April being 0·796, May to June 0.803, July and August, 0·74. Post-larval stages from about 3·5 to 10 mm. were exceedingly common from April to August in the young-fish trawl material.

PLEURONECTES.

The paucity of the eggs of this genus in our samples is greatly due to the fact that, by the time the systematic collection of samples was commenced, the spawning season of the species occurring off Plymouth was more or less over. Moreover, the regions favoured as spawning localities by the plaice (*P. platessa*), dab (*P. limanda*), "merry-sole" (*P. microcephalus*) are in the deep water at some distance from land, to which there is a regular off-shore migration for the colder months of the year, in which period most of the spawning of these species occurs. The flounder (*P. flesus*) is an exception. Seven eggs of this species were taken in four "hauls" in the Sound between 17th February and 4th March, and post-larvae were common in May. No plaice eggs were taken, the spawning being practically over by the end of January. Previously published observations of the occurrence of plaice eggs are confined to the records of the obtaining of one egg on 12th February and 7th March, 1902, by F. Balfour Browne (**2**, pp. 607 and 609). I myself have obtained no specimen of the pelagic post-larva, nor is there any record of such having been taken at Plymouth, due, I believe, to their off-shore spawning region. However, I hope to have more to say as to the distribution of the young Pleuronectidae in a later paper.

P. microcephalus eggs have been most frequently met with, but on five out of six occasions when this egg has appeared in my plankton samples, it has been only a single specimen. The first specimen was taken on 8th April and the last on 24th May, but before that period no off-shore tow-nettings had been collected. The diameter of the egg varied from 1·30 to 1·38 mm. A newly hatched larva measured 4·84 mm. Only one post-larva was taken—in July, off the Eddystone. In previous years, however, this stage has been more abundantly represented in our samples.

No eggs of *P. limanda* were taken, and on two occasions only (in

May and June) were post-larvae obtained. There is one record only of the occurrence of the egg of the dab in the Plymouth neighbourhood, viz. on 14th April, 1902, south of the Mewstone (**2**, p. 613), but this, again, is probably due to the dearth of samples from the off-shore areas.

Solea vulgaris, Quensel. The Common Sole.

The only remark to be made concerning the occurrence of this well-known and easily recognized egg is as to its rareness in our samples, only three specimens having come into our hands through the whole season, viz. one in February at the eastern entrance to the Sound, one in May in the Sound, and one in June in Cawsand Bay. This was probably due to the fact that no samples were collected during practically the whole of March. This month, according to Cunningham (**4**b, p. 117), represents the height of the spawning season, which extends from the middle of February to the end of April. A further cause is the fewness of our samples during this period from the deep off-shore waters where the spawning fishes appear to occur in greater numbers. Pelagic young fish have likewise been very few, less than ten being taken throughout the season from April to the end of August.

Solea lutea, Bonaparte. Solenette.

Holt (**11a**), pp. 460–4, Figs. 9, 10, 46–52.
(**11f**), pp. 87–9.
Ehrenbaum (**5a**), pp. 312–17, Figs. 31–5.

One specimen of the egg of this species was taken in a tow-net at a depth of about 4 fathoms 1¼ miles N. by W. of the Eddystone on 2nd July. It was not perfectly spherical, and measured 0·80 by 0·84 mm. The yolk contained 14 oil-globules of a pale amethyst tint. On the day of capture the embryo had developed a short caudal rudiment. Dull pale yellow pigment was present on the yolk-sac and abundant on the body, and a few black chromatophores were also visible on each. On being next examined, three days later, the larva was found to have hatched out and almost absorbed the yolk. Its total length was 3·01 mm., the distance from snout to anus being 1·03 mm. Dull yellow pigment in large dendritic chromatophores was present on the body, head, snout, and along the margin of the unpaired fins, with the characteristic large patch at the commencement of the posterior half of the tail. There are two large patches and a smaller anterior one on the anal fin. On each well-developed pectoral fin there is a large patch of pigment, which does not appear to have been mentioned by previous observers.

I have not found among my young-fish trawl collections this year any post-larval stages which I can with certainty ascribe to this species.

Solea variegata (Donov). Thickback.

CUNNINGHAM (4a), p. 23, Fig. 15.
(4b), p. 90 ; Pl. XVI, Fig. 6 ; Pl. XVII, Figs. 1 and 2.
HOLT (11d), p. 137.

This is the species of Solea which yielded the greatest total of eggs in our samples, fifteen altogether being taken for the season. Considering the relative abundance of the parent fish, previous records for Plymouth are surprisingly meagre. Cunningham first obtained a pelagic egg of 1·36 mm. diameter in July, which he identified chiefly by comparison with the ovarian egg from a ripe female taken the previous May. In his treatise on the Common Sole, 1890, he figures the newly hatched and two days' old larva, the former being 2·42 mm. in length. He describes the eggs as measuring 1·28 to 1·36 mm. in diameter, and therefore smaller than those of the common sole. It may here be mentioned that there seems to be no evidence for Ehrenbaum's statement (**5**b, p. 143) that it is larger than that of *S. vulgaris,* at least as regards the Channel specimens of the latter species (cf. **7**, p. 23), although observations in the North Sea (where *S. variegata* does not occur) have given a smaller diameter for the eggs of the common sole. Holt (*op. cit.*) records a single egg of 1·11 mm. diameter, taken in the Hand Deeps in July, which died before being completely examined; and Balfour Browne (**2**, p. 615) mentions the taking of one in the West Channel on 21st April, the diameter of which was 1·44 mm.

My earliest specimens (eight in number) were taken by tow-nets 7 miles south-west of the Eddystone on the 8th of April, but I was not able to examine them carefully until a day or two later, when most of them had hatched out. One of the eggs had a diameter of 1·36 mm. The yolk showed a superficial segmented layer and contained about forty oil-globules, more or less uniformly distributed below its surface. The embryo had developed a free caudal rudiment of moderate length. There were many round pale yellow or straw-coloured chromatophores and fewer small black ones on the body of the embyro and on the yolk-sac. The length of a larva, measured about one day, or possibly slightly more, after hatching, was 3·17 mm., from the snout to the posterior edge of the yolk-sac being 1·5 mm.

Three other eggs taken with the young-fish trawl in the Sound on the 3rd May were able to receive more attention. Their diameters were 1·34, 1·36, and 1·30 mm. The first had between forty and fifty oil-globules, varying from 0·015 to as large as 0·12 mm.; the second possessed about fifty and possibly more oil-globules of diameter from 0·015 to as large as 0·12 mm.; the third had only thirty-four oil-globules of diameter 0·024–0·12 mm. At the commencement of the development of the caudal rudiment black and yellow pigment occurs, the former colour in rows of small chromatophores displaying stellate forms. The larva, measured during the first day after the hatching, has a total length of 2·88 mm., the distance from snout to anus being 1·38 mm. The yolk-sac is very globular in shape. Yellow is the prevailing pigment, occurring in large, stellate chromatophores over the body, embryonic fins, and yolk-sac. Large, stellate, black chromatophores are also to be seen over the yolk-sac, but they are not very intense, and they are less numerous than the yellow. Black, stellate pigment spots are also distributed along the body, chiefly on the dorsal region, but at the posterior extremity is a short series of three along the ventral contour. The most conspicuous black pigment is in a series of twenty-five large, irregular, stellate or dendritic chromatophores along the margin of the dorsal fin membrane, extending from the occipital region to about 0·4 mm. from the caudal extremity. There is a similar series along the margin of the anal fin membrane, but consisting of only six chromatophores. This specimen is practically identical with the somewhat older specimen figured by Cunningham in "A Treatise on the Common Sole," Pl. XVII, Fig. 2.

Subsequent specimens of this egg were taken on 29th June 1 mile S.E. by E. of the Eddystone (1 egg of 1·29 mm. diameter), and on 26th August in about the same area (3 eggs, 2 of which measured 1·26 and 1·3 mm. in diameter), in each case in the catch of the young-fish trawl. One or two post-larval stages were obtained in July and August from the deeper layers of water between Plymouth Sound and the Eddystone region.

Solea lascaris, Bonaparte. Sand Sole.

Holt (11a) (Species I), p. 457, Pl. XLIX, Fig. 26; Pl. L, Figs. 34, 35.
(11f) (*? Solea lascaris*), p. 84, Pl. V, Figs. 50, 51.

On 14th March, 1910, a single egg with the segmented yolk cortex typical of *Solea* and containing many oil-globules was taken in the tow-net between Plymouth Sound and the Eddystone. Examined on the 15th March, its diameter was about 1·36 mm., and the oil-globules, which numbered more than fifty, showed a characteristic arrangement. They were not aggregated closely together in opaque clusters as in

Solea vulgaris, nor distributed fairly regularly about the yolk as in *S. variegata* and *S. lutea*, but were arranged so that the majority of them formed a circle round the yolk outside the margin of the blastoderm, while there were also a number closely aggregated into a group at the vegetative poles.

Four days later (on the 19th) the larva was found to have hatched out (see Fig. 11) and was then probably in its first day of larval life. Its total length was 3·46 mm. and its pre-anal length 1·4 mm. The yolk-sac at this stage is very globular, the oil-globules being mostly in the ventral part of it. The head, body, unpaired fins and pectorals (which later become rather conspicuous), and yolk-sac are liberally sprinkled with dull, pale yellow chromatophores, from the well-marked rounded centres of which ramify dendritic outgrowths. There are black pigment spots having generally the same distribution but less numerous, especially on the yolk-sac and unpaired fins. The caudal region, where embryonic fin-rays are making their appearance, is unpigmented. Black is beginning to appear in the eyes. Two days later the yolk is reduced to about the size of the head, but still shows several oil-globules also reduced. The total length is about 3·7 mm.; from the snout to the anus about 1·52 mm. The eyes are black with greenish tints. The midbrain is well developed and the frontal region prominent—of the typical *Solea* type. The mandibular region is also well developed, but the mouth is not yet open. The gut now has a ventral bend above the posterior half of the yolk-sac. The pigment is practically unchanged, except for a concentration into marginal patches along the unpaired fins—six in the anal and nine in the dorsal fin—each patch consisting of a mass of dendritic chrome-yellow, usually with a somewhat dense black spot in the centre. The pectoral fins are large, well pigmented, and generally in active movement. The following day saw a further reduction of yolk, but there was still some left. The gut has now a pronounced U-shaped bend. The mouth is apparently about to open. The pigmentation of the unpaired fins shows further concentration into patches along the extreme margin. Yellow (dull brown by transmitted light) forms the greater part of each patch. The rest of the fins and body are also well covered with dendritic and irregular-shaped chromatophores. The frontal region is further developed and certainly constitutes a remarkable feature of the larva, but is nothing like Holt's drawing of his "Species I—*Solea* (?)" (11a, Figs. 34 and 35).

On the 23rd (viz. four days after the larva was first observed) it showed signs of ill-health and the tip of the tail had become shrunken and crooked. There is still a portion of the yolk left, although the gut is now completely looped. The mouth is now open and conical teeth are visible in the lower jaw. The head is relatively enormous, the midbrain of considerable size and forwardly protruding. The dorsal fin membrane is very deep over the head and anterior part of the body. At this stage the specimen was killed.

A similar egg to mine was taken in July, 1890, in Clew Bay, and has been described by Holt (**11**a). The diameter was 1·38 mm., and the numerous oil-globules had a characteristic arrangement, different from that of the other known British species of *Solea* but resembling that exhibited in my specimen.

The resulting larva, however, was very different from mine, and was especially remarkable for its peculiar cephalic contour caused by a precephalic vesicular expansion of the dorsal fin. The very slight occurrence of black pigment and the limited distribution of the yellow chromatophores in the unpaired fin (*op. cit.*, Pl. L, Fig. 34) constitute another and probably more important difference between that larva and mine. The same authority obtained a second egg in the Gulf of Marseilles (**11f**, *loc. cit.*) of 1·36 mm. diameter and of similar character in regard to its numerous oil-globules, and referred to as "*? Solea lascaris*, Risso." He points out its similarity to Raffaele's "Sp. A" (**20**, p. 43, Tav. 1, Figs. 32 and 33; Tav. 3, Figs. 4–9), which, however, has a smaller egg and more black pigmentation than Holt's, in which latter character it approaches much more nearly to mine. Holt (**11f**, p. 86) is inclined to minimize the importance of this difference, remarking, "que le seul alevin que j'ai vu n'était pas né sous le beau soleil du midi, chose à prendre en compte lorsquon parle de coloration," and since the dorsal precephalic prominence is probably an abnormal and certainly not a constant character (Raffaele, for example, shows it in Tav. 3, Fig. 5 only, and McIntosh and Prince (**16**, p. 850), referring to a similar protuberance over the brain in a single specimen of *Solea vulgaris*, regard it as an abnormal feature), there is much probability that Holt's larva from the Irish egg is the same species as mine, the latter being the more normal form. Ehrenbaum (**5**b, p. 149) does refer it to *Solea lascaris*, suggesting that Raffaele's "Sp. A" on account of the smaller diameter of the egg may probably be *Solea Kleini*, Bp.

THE TOP-KNOTS. (ZEUGOPTERUS.)

I follow Petersen* in referring all three Top-knots known in the Plymouth neighbourhood to the genus *Zeugopterus.* Under this heading, then, we have to consider:—

Zeugopterus norvegicus, Coll. (*Scophthalmus norvegicus,* Gthr.)
„ *punctatus* (Bl.) (*Rhombus punctatus,* Gthr.)
„ *unimaculatus* (Risso), Day. (*Phrynorhombus unimaculatus,* Gthr.)

I have named them in order of the abundance of adults, so far as is known, in the neighbourhood of Plymouth Sound. *Zeugopterus norvegicus* occurs fairly commonly on the Rame-Eddystone ground, and I learn from fishermen that it has been taken in increased abundance of late years. The other two species are more littoral, rock-haunting fish, and therefore do not lend themselves to capture in a trawl to the extent that *Z. norvegicus* does. *Z. punctatus* is not infrequently taken on the rocks between tide-marks, and sometimes finds its way into the shrimp-trawl. *Z. unimaculatus* has not come into our collections in my own experience at Plymouth, and I can only state that it *has* been known to occur here.†

Holt (**11**d, p. 128) and Balfour Browne (**2**, p. 600) have taken pelagic Zeugopterus eggs here in the spring months of 1897 and 1902, but the observations have not yielded sufficient information to enable a definite conclusion to be made as to their identity. I have been more fortunate in obtaining a large number of eggs and in having at my disposal the solution of the identity of one of the species, viz. *Z. norvegicus*, which Ehrenbaum's work at Helgoland has rendered available (**5**b, p. 210).

Below I give a list of all the Zeugopterus eggs taken in my collections in 1909. In the majority of cases they were kept until the just-hatched larva could be observed. It will be seen that they group themselves into two classes, those in Column I having a diameter of 0·75–0·90 mm. and an oil-globule of 0·095–0·15 mm., while Column II contains the larger eggs of 0·96–1·05 mm. diameter and 0·17–0·195 mm. diameter of oil-globule.

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* Report of the Danish Biological Station, XII, 1902–3, p. 26.

† A specimen of *Z. unimaculatus* was, however, taken in the trawl off the Eddystone in May, 1910, after this paper was in manuscript.

I. (*Z. norvegicus*).			II. *Z. punctatus* (? all this species).		
	Diameter			Diameter	
Date.	of egg.	of oil-globule.	Date.	of egg.	of oil-globule.
19–IV	·82	·13	17–II	1·03	·19
,,	·86	·132	20–II	1·04	·17
,,	·84	·13	25–II	1·02	·195
,,	·87	—	,,	1·04	·17
,,	·87	·125	,,	1·02	·18
,,	·88	·125	4–III	1·05	·19
,,	·84	·125	,,	·99 (ca)	·17
20–IV	·90	·15	19–IV	1·01	·19
,,	·83	·13	20–IV	·99	·175 (?)
,,	·845	·14	28–IV	·99	·175
,,	·84	·125	3–V	·96	·18
,,	·85	·10	,,	·98	·18
12–V	·75	·11	,,	·98	·18
18–V	·80	·095	12–V	·99	·18
,,	·84	·12	24–V	1·01	·178
,,	·81	·13	,,	·98	·17
24–V	·86	·13	,,	·94	·175
14–VI	·82	·11	,,	·92	·175
,,	·82	·11	,,	·96 × ·98	·17
,,	·80	·12			
28–VI	·82	·125			
,,	·82	·11			
,,	·84	·12			

I have not the slightest doubt in referring all the eggs of Column I to *Z. norvegicus.* It will be noted by reference to Table I that the localities of their capture belonged in general more to the open-sea waters than is the case for the larger eggs of Column II. Most, if not all, of the latter I ascribe to *Z. punctatus.* Not only do the dimensions of the egg and oil-globule fall into two fairly distinct groups, but also, as far as could be observed, the hatched-out larvae from the smaller eggs exhibited one type of characteristic pigmentation (identified by Ehrenbaum, *op. cit.*, with *Z. norvegicus*), and those from the larger eggs another type of pigmentation, which is identical with that shown by Holt's "Species X" (**11**b, Figs. 20 and 21), referred by Ehrenbaum, with a query, to *Z. punctatus.* I do not doubt but that this is its species. There is only one other species possible and that is *Z. unimaculatus*, a much less common fish in our area. Moreover, the latter has not occurred in our collections of post-larval fishes for the years 1906, 1908, and 1909, although *Z. norvegicus* is common and *Z. punctatus* occasionally recorded in each year for the months April, May, and June. The difficulty, if not impossibility, of distinguishing the egg of *Z. unimaculatus* by its dimensions may be seen by a comparison of measurements of the eggs of this species, which are definitely known from having been obtained from ripe females (·92–·93 mm. for unfertilized, and ·90–·99 mm. with oil-globule ·16–·18 mm. for fertilized ova *) with Column II in the above list. There is indeed one egg (marked with a ?) in the above series which I had some ground for regarding as possibly *Z. unimaculatus*. This was taken on the 20th April in Cawsand Bay. Unfortunately my recorded observations of this egg and the subsequent larva are very meagre. Just before the outgrowth of the caudal rudiment there was no pigment whatever on the embryo. The larva, which hatched out on the 24th April, had a length within the first few hours of larval life of 2·4 mm., the pre-anal length being 1·07 mm. This agrees almost exactly with Holt's newly hatched specimen from an artificially fertilized egg of *Z. unimaculatus* (**11**c, p. 46, and **11**f, Fig. 89). My brief notes upon the larva state that yellow was the predominant pigment, occurring in moderate-sized round and stellate chromatophores over body, yolk-sac and unpaired fins, except at the posterior extremity of the latter. Along the margin of the unpaired fins the pigment was dendritic. Black pigment consisted of numerous very fine dots, scattered with the yellow all over the body, fins, and yolk-sac. However, on the 27th the pigmentation had assumed the same form, which I found at the same stage in the other larvae hatched from the larger group of Top-knot eggs and which I regard as typical of *Z. punctatus*. Its identity with *Z. unimaculatus*, therefore, can be based only upon the dimensions of the egg and newly hatched larva, for which comparison there is still too little material. Of course there is the possibility of a close resemblance between the pigmentation of the later vitelligerous larval forms of the two species.

It will be noticed that my above lists indicate a somewhat different period for the occurrence of the two groups of eggs, Group I (*Z. norvegicus*) being taken from 19th April to 28th June, and Group II (*Z. punctatus*) from 17th February to 24th May. This difference is, however, probably more apparent than real, for before April I was not able to get any samples from further seaward than the entrances to Plymouth Sound, which would leave the habitat of *Z. norvegicus* neglected for the commencement of the season.

I may now give a more detailed account of the characters and especially the pigmentation of the two undoubtedly occurring species.

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* Cf. Holt, 11d, p. 128.

Zeugopterus norvegicus, Coll. Norwegian Top-knot.

The oil-globule is commonly pale green and the yolk-sac slightly rugose. Before the outgrowth of the caudal rudiment the periblastic pellicle of the oil-globule becomes visible, and fine black chromatophores appear on the embryo and yolk-sac. They are very closely set on the former but less dense and mostly stellate in form on the latter. Over the whole embryo and yolk-sac there is a pale greenish yellow tint, but no separated, coloured chromatophores are visible as yet. Yellow pigment cells soon appear on the embryo and yolk-sac, and by the end of embryonic life they become conspicuously predominant. The black chromatophores show dense, rounded centres, from which fine ramifications proceed. Some of the few yellow chromatophores on the yolk-sac are stellate, with no specially large centre. On the trunk of the embryo, just before hatching, they are large and of vague outline, and so close together as to give the effect of a diffuse tinting along the whole length of the body, except the extreme caudal end. Black pigment is fairly uniformly distributed over the body, but shows some concentration into dorsal and ventral lines. A newly hatched larva measures 2·58 mm., with a pre-anal length of 1·16 mm. The snout projects conspicuously forward over the yolk-sac, and the anus is situated some little distance behind the posterior end. Ehrenbaum (*op. cit.*) describes the position of the oil-globule as usually at the middle of the ventral side of the yolk, but I have generally found it post-median. The pectoral fins are well developed. The pigmentation is extremely rich. A diffuse yellow effect, which is evident to the naked eye, is produced by the close proximity of the large chromatophores (greenish yellow by reflected light), which are distributed over the body, fins, and yolk-sac, most densely along the dorsal and ventral contours and the upper and lower margins of the unpaired fins. Black chromatophores are more abundant, but smaller and much less conspicuous. A very characteristic feature is the stopping short of the pigmentation of the unpaired fins some little distance from the caudal extremity, so that this part of the larval tail is quite clear. The same arrest of yellow chromatophores is seen on the body itself, but small black pigment spots occur as far as the posterior extremity. A further conspicuous character of this species is the regular, fringe-like arrangement of both the black and yellow pigment along the outer margin of the unpaired fin, in the early stages of the larval development. The fringe-like effect is accentuated by the finely pectinate form of the chromatophores in this region. With the absorption of the yolk the intensity of the yellow pigment increases, although undergoing little change in distribution. At 3 mm. length, for example, with the yolk almost absorbed, the general arrangement of pigment is as above. Head and body (except posterior extremity) appear of an almost uniform bright yellow. In the anterior half of the post-anal region the notochord shines white through the yellow, but in the posterior part the yellow is so dense as to obscure it. The coloured pigment is more concentrated on the head, along the dorsum, and about the rectum. The fringe formed by the line of closely applied dendritic or pectinate chromatophores along the margin of the unpaired fins, has a somewhat brownish tint, which is not seen on other parts of the larva. In the anal fin, the fringe begins some distance posterior to the anus. Black pigment is most dense on the ventral surface at the level of the pectoral fins and above the anterior part of the remains of the yolk-sac, where the vestige of the oil-globule now measures about 0·03 mm.

A larva in which the yolk had been fully absorbed (ca. 3 mm. long) showed less distinctness as to the marginal pigment, and a concentration—more particularly of the black chromatophores—in the pigment of the unpaired fins, about half-way between the anus and caudal extremity.

Reticulate markings and small papillae on the epidermis are commonly found both in late embryonic and in larval stages.

To summarize the main facts ascertained for *Z. norvegicus*:—The spawning season, in the Plymouth neighbourhood, extends from April to June, probably beginning somewhat earlier than the former month. The pelagic eggs have a homogeneous yolk and a single oil-globule, which is frequently of a greenish yellow tint. The average diameter of the egg is 0·854 mm. in April and 0·817 mm. in May and June, the limits lying between 0·75 and 0·90 mm. The oil-globule measures 0·095–0·15 mm., the average diameter being 0·122 mm. Embryonic yolk-sac and larval pigments are yellow (bright greenish yellow by reflected light) and black, the former predominating and being visible to the naked eye in the larva. The body and yolk-sac of the newly hatched larva are rather elongate, the total length being about 2·58 mm. (Ehrenbaum gives 2·52–2·76 mm.). The anus is situated a short distance behind the posterior edge of the yolk-sac, and at about $\frac{6}{13}$ the body length from the snout. The characteristic feature of the vitelligerous larva is the marginal pigmentation of the unpaired fins and their total lack of pigment in the caudal region.

Zeugopterus punctatus (Bl.).

Before the outgrowth of the caudal rudiment, the body of the embryo is beset with fine, black chromatophores which are chiefly, if not entirely, on the dorsal surface. A few black chromatophores of larger size are found over the oil-globule, and there may be a small number of black spots on the yolk-sac, which is beset with a moderate number of roundish, yellow chromatophores. The latter pigment occurs in smaller spots on the head and body of the embryo. At this stage the perivitelline space is somewhat large, and the oil-globule is contained in a very distinct periblastic pellicle.

With the growth of the free caudal region (Fig. 2) a marked increase in the size and number of chromatophores takes place. The yellow spots over the yolk-sac now acquire a stellate form, but on the embryo they still occur as patches disposed over the head and body. Yellow does not extend quite to the tip of the caudal extremity as the black does. The black chromatophores over the oil-globule have increased in number, and are the largest of all. Over the yolk-sac they are small and sparingly scattered. Minute black specks occur over the whole body, from anterior to posterior extremity, being most concentrated along the dorsal and ventral contours, dendritic outgrowths from which extend to the embryonic fin. The pectoral fins are relatively well developed, and rudiments of the pelvic fins are visible.

Three larvae observed soon after hatching (Fig. 9) had lengths of 2·90, 2·92, and 2·93 mm., the pre-anal lengths being respectively 1·44, 1·40, and 1·45 mm. The anus is therefore appreciably nearer the median position than in the case of *Zeugopterus norvegicus*, which otherwise it very closely resembles both in general form and in the distribution of its black and yellow pigmentation, the former occurring in mostly small, fine specks and the latter in large, stellate chromatophores. The yolk-sac is elongate and bears the much-reduced oil-globule at its posterior end. As in the above species, the marginal pigment of the unpaired fins is of most diagnostic importance. Immediately after hatching I found some resemblance to the arrangement in *Z. norvegicus*, but the "fringe" formation is not so well marked, and within one day a striking change has taken place which appears to be quite characteristic of *Z. punctatus*, at least as distinct from *Z. norvegicus*. I can, of course, make no comparison with *Z. bimaculatus*, though it is to be noted that Holt's newly hatched larva from an artificially fertilized egg of *Z. bimaculatus* showed no fringe-like occurrence of pigment along the upper and lower margins of the unpaired fins, which I observed in my larvae of both species.

The one-day-old larva (length 3·42 mm.) shows a complete modification of the marginal fringe of the early stage by its breaking up into a series of separate large pectinate and dendritic patches, eight of these patches occurring in the dorsal and five in the anal fin. This exactly resembles Holt's "Species X" (**11**b, Figs. 20 and 21), which Ehrenbaum (**5**b, p. 206) considers as probably identical with *Zeugopterus punctatus*. Besides the above-mentioned characteristic, large, marginal chromatophores, in each of the unpaired fins there is a series of fairly large stellate chromatophores, midway between these and the trunk contours, a single row in the dorsal and a double row in the anal fin. The last 0·5 mm. of the tail end is free from pigment in the fin membrane, but fine black chromatophores extend to the caudal extremity of the trunk. Yellow and black chromatophores are scattered fairly uniformly over the whole body, with a certain amount of concentration along the dorsal and ventral contours.

On the third day (Fig. 10) still further local concentration into patches has taken place, but the general form of the pigmentation remains the same. Black pigment now appears in the eye, and the prominent pectoral fins bear dendritic yellow and rounded black chromatophores. The yolk-sac—with the yolk somewhat more than half absorbed—is very elongate, so that its ventral contour is practically straight.

To summarize:—The spawning season of *Z. punctatus* in this neighbourhood extends from the middle of February to May. The pelagic eggs have a homogeneous yolk and one oil-globule. The diameter of the egg averages 1·03 mm. in February–March and 0·98 mm. in April–May, the limiting sizes being 0·92 mm. and 1·05 mm. The diameter of the oil-globule is 0·17–0·19 mm. Embryo and yolk-sac bear black and yellow pigment, the latter becoming conspicuously predominant in the late embryo and larva. Within one day after hatching, the larva exhibits characteristic stellate or pectinate and dendritic patches of yellow pigment associated with black in its unpaired fins, usually eight in the dorsal and five in the anal fin. The newly hatched larva measures 2·90–2·93 mm. (or possibly less), and the anus is only slightly (if at all) anterior to the median point.

GADUS.

Our tow-net samples of Gadus eggs have not been sufficiently numerous to enable certain conclusions as to their identity to be made in the great majority of cases. This is not due to the absence or scarcity of members of the genus from our neighbourhood, but to the fact that the open-sea water some distance from the coast was not townetted till April, when the spawning season of the Plymouth gadoids is almost over. It is a fact of common knowledge to the Plymouth fishermen that the whiting (*G. merlangus*), bib (*G. minutus*), pout (*G. luscus*), and pollack (*G. pollachius*) are to be found nearer the shore in summer and autumn than in winter and early spring, when the breeding season occurs. This habit of migrating to deeper water for the colder months of the year they have in common with the other important food fishes of the Plymouth district, such as the Pleuronectidae and gurnards. Very many more observations, both physical and biological, are necessary before definite conclusions can be made as to the real causes of these phenomena. The off-shore migration in winter and the corresponding approach to shallow water in summer may, in some cases, follow the seasonal distribution of food, but I do not think this is at most more than a partial explanation. The fact that the temperature of the water in the deeper parts of the Channel is appreciably higher than that of the more inshore parts of the Channel in the coldest months of the year, may be taken as a sufficient reason for the majority of fishes preferring to seek the outer grounds at this time. That conditions directly related to the phenomenon of spawning are involved in this migration (which certainly coincides with the ripening and liberation of the sexual products of most of the species) may be concluded from analogy with the cases already worked out under less complicated conditions, e.g. the plaice and cod, by Johs. Schmidt (21c), who has shown that these and other species show a special sensitiveness to external conditions, especially of temperature, in relation to spawning, and therefore make special and well-marked migrations.

So far I have not been able to obtain direct proof of extensive spawning of our four common Plymouth species of Gadus on the off-shore grounds because winter samples of plankton from such regions have not been collected, but the general fact may be taken for granted. With due precautions one may accept the occurrence of pelagic post-larvae, such as were captured in the young-fish trawl in April and subsequent months, as evidence giving more or less quantitative information as to the spawning times and the relative extent of the reproduction of the various Gadus species in this neighbourhood. As far as can be judged from our takings of the small fry—and evidence from the fisheries points to the same conclusion for the adults—*Gadus merlangus* is the most abundant, very many post-larvae of this species having been taken, especially in May and June. Next in abundance comes *G. minutus*, which has an almost similar period of occurrence, if anything earlier than the whiting. The early pelagic post-larval stages of the pollack have always in my experience been less common than the two foregoing, but they are very abundant, at a size of about 5 cm., close up to the rocks on the shores of the Sound. Post-larval stages of *G. luscus*, which appears to be the least abundant of our four common representatives of the genus, are not infrequent but are never numerous, and they disappear from the samples somewhat earlier than the other three.[*] Other species, such as *G. morrhua* (cod) and *G. virens* (coal-fish), are known, but are very occasional spawners in this neighbourhood.

The specific identification of the pelagic ova by the form and pigmentation of embryo and larva is difficult and sometimes impossible, owing to their great similarity. Pollack, indeed, is said to show no yellow pigment at all in the embryo and early larva (**14**e, p. 171), while the other three species above mentioned as common to these waters do so to a greater or less extent. We cannot feel that we are on safe ground here, however, in dealing with individual fishes on this point, since the *G. minutus* larva is described by Raffaele from the Mediterranean and by Holt from the west of Ireland as having only black pigment, and in several cases the appearance of yellow chromatophores has been noted as an accompaniment to an unhealthy condition (cf. **11**d, p. 140).

The impossibility of separating the species with certainty by reference to dimensions of the ova is indicated by the list which I give below of measurements of eggs taken from ripe female fishes.

Species.	Diameter of Egg.	Month.	Authority.
G. minutus	0·95–1·07	—	Ehrenbaum
	1·02	April	Cunningham
	0·9906–1·0287	—	McIntosh
	1·07	—	Holt
	A little below 1 mm.	—	Raffaele
G. luscus	1·05–1·15	—	Cunningham
	1·13[†]	January	Holt
G. pollachius	1·14	—	McIntosh (artificially fertilized egg)
	1·13	—	Holt

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[*] A general idea of the seasonal occurrence of the young fry may be obtained from the following particulars taken from my records for 1909 of catches of the young-fish trawl :—

G. merlangus . .	First	specimens	(5–10 mm.)	taken	28th April.
,, . .	Last	,,	(9–12·5 mm.)	,,	20th July.
G. minutus . .	First	,,	(ca. 5 mm.)	,,	28th April.
,, . .	Last	,,	(26 mm.)	,,	20th July.
G. pollachius . .	First	,,	(22 mm.)	,,	24th May.
,, . .	Last	,,	(6 mm.)	,,	6th July.
G. luscus . . .	First	,,	(6 mm.)	,,	28th April.
,, ...	Last	,,	(7 mm.)	,,	2nd June.

[†] This is the diameter of the largest unfertilized ovarian egg observed.

Species.	Diameter of Egg.	Month.	Authority.
G. merlangus	1·125	—	McIntosh and Prince (artificially fertilized)
	1·226–1·352	March	Heincke and Ehrenbaum (artificially fertilized)
	1·1–1·226	April	Heincke and Ehrenbaum (artificially fertilized)
	1·069–1·163	May	Heincke and Ehrenbaum (artificially fertilized)
	1·161–1·257	April	Williamson (artificially fertilized)

From this evidence we can merely state that the average size of the egg shows an increase in the order in which the species are enumerated above, but the difficulty arising from overlapping is sufficiently formidable, seeing that the largest size for *G. minutus* may be larger than that of the smallest whiting.

The size of the newly hatched larva shows variation, which may to some extent be taken as a guide to the species, but on this point, to an even greater degree than is the case with regard to the egg, the data hitherto available are very scanty and afford little satisfactory information. With some degree of certainty we may take it that the *G. minutus* larva is the smallest, but no measurement of the product of artificial fertilization is on record. Holt (**11**b) records as *G. minutus* a larva of 2·75 mm. length hatched from a pelagic egg of 1·07 mm. The *G. luscus* larva is probably bigger, and that of *G. merlangus* is certainly bigger still. Ehrenbaum (**5**d, pp. 234 and 238) gives ca. 3 mm. or somewhat smaller for the former and 3·2 to 3·5 mm. for the latter species. *G. pollachius* is so far too imperfectly known for us to state anything as to its larval dimensions. Holt (**11**d, p. 141) ascribes to this species certain pelagic ova of 1·40 to 1·45 mm. diameter taken in February, and mentions that the larva was 4·2 mm. long and had black pigment only. There seems to me to be little doubt as to the correctness of this identification, and it seems probable that further investigation of the eggs and larvae of this species will prove them to be larger in general than those of *G. merlangus.*

The dimensions of all the Gadus eggs measured during the season are as follows:—

February	Diameter	·95	·96	·97	·99	1·00	1·07	1·16 mm.
	No. of eggs	3	1	1	1	1	1	1
April and early May	Diameter	·94	1·08	1·09	1·14	1·13 × 1·17 mm.		
	No. of eggs	2	1	2	3	1		
June–August	Diameter	1·02	1·03	1·04	1·05	1·06	1·12 mm.	
	No. of eggs	1	1	2	1	1	1	

Gadus minutus and *Gadus luscus*.

On 8th April a ripe female *G. minutus* was taken in the trawl about 7 miles south-west of the Eddystone. Eleven ova from this measured 0·91–1·02 mm., the average diameter being 0·939 mm. Artificial fertilization was attempted, but development was stopped by death at the blastula stage. Eight eggs taken in the tow-nets on the same day and in the same locality had diameters of 0·94, 1·08, 1·09, 1·13, 1·14 (two eggs), and 1·13 × 1·17 mm. (the last not exactly spherical). The embryonic form of all appeared practically identical. Round and dendritic black chromatophores first appear on the embryo, and at a later stage a diffuse yellowish tint appears over both embryo and yolk-sac. Just before hatching the black chromatophores are most densely distributed in the posterior half, and there is little or none of this pigment on the head. One or two black stellate chromatophores usually appear on the yolk-sac,* to which also outgrowths from the pigment cells in the otocystic region generally extend. The head and anterior part of the embryo are covered with a diffuse greenish yellow tint; the yolk-sac occasionally shows distinct yellow chromatophores at this stage, but more usually is also diffusely tinted. Only once I noticed distinct chromatophores on the embryo before hatching. I noted no pigment on the embryonic fin at this stage. Two larvae hatched out from eggs of 1·08 and 1·09 mm. diameter measured (a) 2·65 mm., of which 1·35 mm. was the pre-anal length, and (b) ca. 2·9 mm. with a pre-anal length of ca. 1·5 mm. A third larva, (c), slightly more than twenty-four hours old, measured 2·9 mm. total length (1·2 mm. from snout to anus). This was from the egg of 1·13 × 1·17 mm. diameter. A fourth larva, (d), from the egg of 1·14 mm. diameter, measured when the yolk was absorbed, had a length of 3 mm., of which 1·28 mm. was pre-anal. The pigmentation consists of black chromatophores mostly dendritic, distributed along the dorsal and ventral contours, in the peritoneum, a little on the top of the head and about the pectoral region. In specimen (a), however, the pigment extends to the tip of the caudal region, while in (b), which has heavier pigmentation, the last 0·3–0·4 mm. of the tail is bare.

This difference, considered together with the difference of larval size, suggests a difference of species which was impossible to detect in the two eggs so similar in general character and only differing by 0·01 mm. in diameter. From which egg each larva was produced I am not able to state, because I had kept them together in the same vessel, regarding them as of the same species; but the very similarity of eggs makes this point a matter of indifference. The larva (a), which is 2·65 mm. long and pigmented to the caudal extremity, I regard as *Gadus minutus.* Larva (b), on the other hand, which is slightly larger (ca. 2·9 mm.) and shows heavier pigmentation, stopping short so as to leave the caudal extremity bare, I consider is very probably *G. luscus* (cf. **10**, Taf. X, Figs. 20 and 21). Larva (d) (length 3 mm. with yolk absorbed) resembles (b), the posterior 0·5 mm. of the caudal extremity being unpigmented. The small size for this stage of development does not rule out the probability of its being *G. luscus.* Larva (c) shows black pigment of less intensity, most of it occurring along the ventral post-anal contour as far as the caudal extremity and above the gut. There are only four dorsal post-anal chromatophores, and these are not nearly so strongly marked as the ventral ones. This I regard as *G. minutus*, especially on account of there being a distinct resemblance to the early post-larval forms of this species, which have been carefully described by Schmidt (**21**a and b), and which are common in my own collections. In the same way the bare-tailed larvae (b) and (d) suggest the now well-known larval pout.* As to the occurrence of yellow pigment, all four specimens showed yellow chromatophores, with more or less distinctness on body, unpaired fins, and yolk-sac, but in the post-vitelligerous specimen (d) this colour had almost vanished except from the head (cf. McIntosh, **14**c, p. 240).

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* This was noted on eggs which gave rise to different types of larvae, e.g. (a) and (b). See above.

Three planktonic eggs of 0·95 mm. diameter, which were taken in the West Channel (entrance to Plymouth Sound) on 11th February, may be either *G. minutus* or *G. luscus.* One-day-old larvae measured 2·95 and 2·8 mm. The black pigment consists of relatively large stellate chromatophores on the head, a dorsal series which become smaller and less closely placed towards the posterior extremity, and a much weaker ventral series consisting of about nine post-anal chromatophores and a faint line dorsal to the gut. There are small specks of yellow pigment on the body and embryonic fins, most strongly marked along the body contours and along the proximal margins of the fins, but very faint in the caudal region. The larval pigment at this stage cannot be said to show any approach to either the bib or pout type of post-larval pigment. It resembles *G. merlangus*, but the small size seems to preclude that species. A larva of similar character hatched from an egg of 1·00 mm. diameter, taken from the same locality on 25th February, measured ca. 2·75 mm. when more than a day old.

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* While using this similarity of larval pigment to that of definitely known post-larval stages as evidence assisting to indicate the identity of a larva hatched from a Gadus egg taken in the tow-net, I think it necessary to point out that this similarity should not always be expected in the larval stages. As positive evidence it is helpful, but as negative evidence it is without value. Under certain conditions—chiefly of higher than normal temperature—I have noticed a precocity in development of pigment. The same phenomenon has been noted by Holt (cf. **11a**, p. 454).

The next noteworthy capture of Gadus eggs took place late in August, an unusual time for the spawning of any members of the genus in our area. On 26th August two eggs of 1·02 and 1·06 mm. diameter were obtained in the young-fish trawl, but they died before hatching. The following day six eggs were captured of diameter 1·03–1·05 mm. In embryonic characters these resembled what I have above described as *G. luscus*. An early larva from one of them had a length of ca. 2·5 mm. A second larva which had absorbed practically all its yolk was 3·32 mm. long, of which 1·22 mm. was pre-anal. At this stage the anus was still apparently imperforate; the eyes dark blue with considerable black pigment, the mouth large with the relatively massive lower jaw slightly protruding. There is well-marked indentation behind the mid-brain and a typical large supra-cephalic ampullation, which extends as far back as the level of the anus. The pectoral fins are large and fan-like. The type of pigmentation strongly suggests *G. luscus*. Black chromatophores are distributed post-anally as very distinct dorsal and ventral lines, which stop short at a distance of ca. 0·9 mm. from the posterior extremity, so that the last part of the tail is quite unpigmented. The dorsal line arises in the occipital region and the ventral at the base of the pectoral fin, whence it continues backwards at the level of the dorsal edge of the gut. There is also black pigment at the tip of the snout, at the end of the mandible, below the throat, and a few lateral chromatophores on the trunk. In this specimen the latter were adjacent to the dorsal series, but in another they were mainly on the ventral half of the body posterior to the anus. No yellow pigment at all was observed in the late larval stages. The early larvae were very cursorily examined and I have no notes as to the presence of this colour. In the embryonic development a diffuse yellow tint was visible on the yolk-sac and about the contours of the trunk.

Gadus merlangus.

Only three eggs in all were taken, which may with probability be referred to this species. The first, taken at the western entrance to the Sound on 25th February, was 1·16 mm. in diameter, but was killed by the low temperature before hatching. The second was obtained from a haul of the young-fish trawl in Cawsand Bay on 28th April. No record was made of the size of the egg, but the newly hatched larva had a length of 3·44 mm. (pre-anal length, 1·42 mm.)

and the yellow and black pigmentation typical of *G. merlangus*. A third whiting egg was taken on 12th July, about 1½ miles south of Rame Head. The diameter was 1·12 mm. and the length of the larva within the first day 3·58 mm., the distance from snout to anus being 1·58 mm.

The fewness and infrequency of the appearance of whiting eggs in my collections are undoubtedly due to the fact that our tow-nettings have not been taken anywhere near the off-shore breeding haunts of the species at the time of their spawning season.

Onos, Risso (= Motella, Cuvier). The Rocklings.

It is an open question whether our knowledge of the occurrence of the members of this genus in the Plymouth neighbourhood is complete and exact, but certainly the presence of more than one species has complicated the task of fully identifying the rockling eggs, which have long been well known as occurring here in abundance. The most common species found here is *O. mustela*, L., and *O. tricirratus* (Bloch) is also known, while Holt (**11**d, p. 143) speaks of "the undoubted existence in the district of *M. cimbria* and *M. maculata*, and possibly of other forms which may require specific distinction." I have no personal knowledge of the occurrence of the two latter species, but I may mention that a form identified as *Motella fusca*, Moreau, by Garstang and Balfour Browne was taken in April, 1901, on the shores of Plymouth Sound.*

However, the problem of denoting the species of the pelagic ova commonly occurring at Plymouth, is mainly one of deciding which other species besides the abundant *O. mustela* are represented. My task of identification has been aided by the recent publication by Ehrenbaum (**5**c, p. 237, and **5**d, p. 284) of descriptions of the ova and larvae of *O. mustela*, L., and *O. cimbrius*, L. In regard to the latter species I need only say that it does not appear to be represented in my samples of ova, nor do I know of any record of the occurrence of the adult in this district.† *O. mustela*, on the other hand, is the prevailing species, and what I was led to expect, from the abundance of the fish in Plymouth Sound, is confirmed by comparison with Ehrenbaum's description of the egg and larva of the species. He gives the average diameter of the ova of *O. mustela* as varying (off Heligoland) from 0·878 mm. in February to 0·736 in June, and the peculiar pigmentation of the late embryo and early larva as the chief diagnostic character (at least as far as distinguishes it from *O. cimbrius*), viz. the arrangement of the post-anal black pigment into two groups, the first a short distance behind the anus, usually confined to the ventral half of the body, the second in the form of a band from the dorsal to the ventral contour, besides which there is, in the hypural region, a small patch of pigment which has outgrowths to the marginal fin. *O. cimbrius* shows only one of these post-anal pigment groups.

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* *Journ. M.B.A.*, N.S., VI., p. 626.

† A small immature specimen of *O. cimbrius* was, however, taken in Whitsand Bay on the 3rd March, 1910, which is, I believe, the first record of the species for the Plymouth neighbourhood.

Onos mustela, L.

To come to the consideration of my own specimens, they can with very little exception be designated *Onos mustela.* There is, of course, the bare possibility that the eggs and larvae of some other species of rockling, which are at present unknown, may so closely resemble those of *O. mustela* as to have been indistinguishable from them by me. But even if such were the case, the number so included would be quite inappreciable against the total, which are undoubtedly *O. mustela.* These eggs occurred in my tow-net and young-fish trawl plankton samples from 11th February to 25th June, and again in August and September. The diameter varied from 0·72 to 0·83 mm., averaging 0·77 for February to March, 0·78 for April, and 0·72 for May to June. The diameter of the oil-globule varied from 0·13 to 0·18 mm. It sometimes happened that the size of the oil-globule was the reverse of being proportional to the size of the egg, i.e. the larger eggs of a sample had the smaller oil-globules, which I thought might possibly be significant of a specific difference, but observations of the resulting larvae disproved this. The oil-globule, which may be subdivided into two or three in the early stages, commonly has a more or less greenish and sometimes a cupreous tint. The yolk surface is somewhat corrugated. By the time the embryo has developed a caudal rudiment, small black chromatophores appear generally in a double line along the body, on the head, and in the pellicle of the oil-globule. They soon increase in size, and may become stellate, especially the anterior ones. Just before hatching the two characteristic post-anal groups (or "zones") of pigment are generally quite distinct. One of my smallest newly hatched larvae measured 1·88 mm. (the pre-anal length being 0·76 mm.), and the largest size I have recorded for this stage is 2·32 mm. The black pigment, which is mostly stellate and dendritic, is distributed upon the head, in the peritoneum, over oil-globule, laterally on the trunk over the anus, in the two large distinct post-anal groups above mentioned, and in the hypural region. These groups or zones are formed by the occurrence of short dorsal and ventral bars of black pigment spots, more or less fused together, from which dendritic outgrowths extend laterally. Sometimes such a bar may consist of only two or even one large chromatophore. Ehrenbaum states that the anterior group is usually confined to the ventral half of the body, but I have very often found it possessing a well-marked dorsal bar. The extent and intensity of these bars and groups of pigment, however, are subject to some variation. With the absorption of the yolk the post-anal pigment diminishes, especially in regard to the dorsal chromatophores, and when the yolk is entirely absorbed the latter have generally—though not always—entirely disappeared, leaving three relatively small chromatophores along the ventral contour corresponding to the three previous groups. At this stage the pectoral fins are well developed; but the ventrals, which soon afterwards become such a conspicuous feature of the post-larva, are rudimentary. My *O. mustela* eggs were taken for the most part in Plymouth Sound and some in Cawsand Bay, while none were taken in more open water than Whitsand Bay, which is in keeping with the littoral haunts and the *penchant* for the vicinity of brackish water of the parent fish (cf. Holt, **11**d, p. 143).

Onos, Species A (*? tricirratus,* Bl).

Two eggs which may probably be referred to this species occur in my samples, one taken on 28th June 3 miles S. by W. of Rame Head, and the other taken on 30th August 3 miles W.N.W. of Rame Head. The identification is chiefly based upon the similarity of the larva to that of *O. tricirratus*, described by Raffaele (**20**, pp. 37 and 38, Tav. I, Figs. 26 and 27; Tav. III, Figs. 2 and 3) from an egg of 0·74 mm. diameter, which had an oil-globule of 0·218. The larva is characterized by the possession of less pigment than *O. mustela* or *O. cimbrius*. It is practically limited to one clearly defined zone of black pigment across the middle of the post-anal part of the body and a line of peritoneal pigment dorsal to the gut (*op. cit.*, Tav. III, Figs. 2 and 3). The earlier of my eggs had a diameter of 0·84 mm., and the later one 0·78 mm. The oil-globules measured respectively 0·16 and 0·145 mm. The embryonic pigment spots, which are small at their first appearance, become in the later stages relatively large in size, although few in number. The isolated mid-post-anal group of chromatophores is very conspicuous. In my second specimen I noted that this group consisted of six ventral chromatophores with three dorsal and two lateral ones, which, before hatching took place, formed a dense band around the embryo by their enlargement and partial fusion. Black appears in the eyes shortly before hatching. In both specimens only one chromatophore was to be seen over the oil-globule. The newly hatched larva from my later egg (Fig. 14) measures 2·32 mm., of which 0·94 mm. is pre-anal. That from my June egg, measured when about one day old, had a length of 2·42 mm., from the snout to the anus being 1·0 mm. The pigmentation of the former consists of a very conspicuous mid-post-anal patch, made up of a large dorsal and a large ventral chromatophore (the latter accompanied anteriorly by a relatively small pigment spot), a small hypural patch, while pre-anally there is a group of chromatophores on the side of the body in the pectoral region, a series dorsal to the gut, one large dendritic chromatophore below the anus and extending partially over the oil-globule, and some pigment in the eye and on the head. The pigmentation of my second larva at a slightly older stage, when most of the yolk had been absorbed, differed only from the above in being somewhat more densely aggregated. Two large dendritic chromatophores—one dorsal and one ventral—with outgrowths extending laterally as far as the notochord, constituted the mid-post-anal group, a continuous line of dendritic pigment ran along the whole peritoneal region, one large dorso-lateral patch of pigment occupied that part of the trunk above the base of the pectorals, two small chromatophores were on the head, and the iris was now completely black. Holt (**11**b, Pl. VI, Fig. 53) has figured a larva ("Species III (Motella?)") somewhat similar to this, but having an anterior group of post-anal pigment spots much resembling that of *O. mustela*, which it also approaches in having many pigment spots over the oil-globule. Ehrenbaum (**5**d, p. 278) considers this may possibly be *O. tricirratus*, Bl. The egg had a diameter of 0·72 mm. (and less) and an oil-globule of 0·17 mm., and the larva in its first day was 2·20 mm. long. My larvae certainly have a closer resemblance to Raffaele's *O. tricirratus*, Bl., than this of Holt's. I may mention, however, that Ehrenbaum (*ibid.*) warns one not to attach too much weight to Raffaele's identification of the parent fish as *O. tricirratus*, Bl., suggesting that the Naples observer did not wish to designate this species as distinguished from *O. mediterraneus* (L.), but merely referred to the common tricirrate form of the Bay of Naples, which appears to be *O. mediterraneus* (L) (= *O. tricirratus*, Brünnich), and not *O. tricirratus*, Bloch (= *Onos vulgaris*, Yarr.). I do not see, however, that there is any solid ground for doubting Raffaele's identification in this case.

Onos, Species B.

A much more problematic form of larva, which I will term "Onos, sp. B," was hatched from a rockling egg taken in the young-fish trawl 2 miles S. of Rame Head on 2nd June. The egg had a diameter of 0·68 mm., and its oil-globule 0·145 mm. When the embryo had developed a short free caudal portion, it was marked with large black pigment spots, and the stellate chromatophores in the pellicle of the oil-globule were noted as being especially large. On the 5th of June the larva had hatched out. Its length when about one day old was 1·84 mm. (pre-anal length = 0·84 mm.). It showed the Motella characteristics as described above, except as regards the distribution of pigment in the pre-anal part of the body, which was practically wholly dorsal (see Fig. 15). From the snout to beyond the middle of the post-anal part, there was a series of black chromatophores, most of which were large and possessed outgrowths extending over the upper part of the sides of the trunk, often as far as the level of the notochord. The most posterior group of this series contributed the dorsal bar of the typical *Onos* mid-post-anal zone. The corresponding ventral bar was present, as well as the usual hypural patch, but the only other pigment consisted of a single chromatophore below the anus and a group over the posterior part of the oil-globule. The absence of pigment from the peritoneal region is remarkable, and this fact especially inclines me to the view that we may possibly be dealing here with an abnormal specimen. Apart from this the pigmentation bears some resemblance to that shown by *O. cimbrius* (Ehrenbaum, *op. cit.*). From my present knowledge of Plymouth species of rocklings, however, I will not venture to suggest a definite species. Assuming that it is normal, it is certainly not *O. mustela* nor *O. cimbrius;* and if my previously described larva (*Onos,* sp. A) is indeed *O. tricirratus*, Bl., that species is also excluded. It seems to me that my "Onos, sp. A" may with far more probability be referred to *Onos tricirratus*, Bl., than may "Onos, sp. B." Then, by a process of exhaustion—always bearing in mind, however, that our knowledge of local Onos species cannot safely be regarded as complete —we have left *Motella fusca*, Moreau (which may probably be regarded with *M. maculata* of the same authority as varieties of *O. mediterraneus*, L.). It is at least possible that "Onos, sp. B," the larva with a pre-anal dorsal row of chromatophores and no peritoneal pigment, belongs to this species.

Raniceps raninus, L. Frog-fish.

Four eggs identified with this species were taken from a young-fish trawl, mid-water haul, in Whitsand Bay on 30th August. Holt obtained eggs of the same species from tow-nettings taken at various depths off Plymouth, in June, July, and August, 1897, which he recorded as unidentified but with apparently gadoid characters (**11**d, p. 145). In his Irish survey the same investigator had previously met with a similar egg and had described and figured it, with the twelve-hour-old larva, as "Species VIII" (**11**a, p. 471, Figs. 27 and 36). He embodies his observations upon both Irish and Plymouth material in his Marseilles Museum Annals Memoir, suggesting as the possible parent fish *Phycis blennoides*, a rare visitor to this coast and one which had probably arrived in the track of the shoals of mackerel and scad (*Caranx trachurus*), which were present in unusual abundance in the inshore waters at the time of his Plymouth observations. Since that time, there have been no observations of planktonic fish eggs in the summer months here until the present year, so that the solution of the question as to whether the eggs belonged to a constant or intermittent visitor to these shores by the plan of noting the presence or absence of the eggs in successive years, has not been possible. It so happens that the present summer (1909) has also been characterized by a greater than usual abundance of mackerel and scad in the inshore waters of the Plymouth area, but whether this condition can be correlated with the presence of these eggs is doubtful. Heincke and Ehrenbaum (**10**, p. 258) have subsequently observed the egg as regularly occurring with summer plankton off Heligoland, and since *Phycis blennoides*, the only other fish to which it could with any probability be ascribed, is never found in Heligoland waters, they have identified it with *Raniceps raninus*—a quite well-founded conclusion, although the absolutely unquestionable identification by tracing back the egg to the parent still remains unaccomplished, since the ripe female is as yet unknown. Holt's Irish specimen measured 0.775 mm. and had a colourless oil-globule of 0·14 mm. diameter. The larva about twelve hours after hatching measured 2·68 mm. Those taken by him at Plymouth at the end of June and in July measured from 0·84 to 0·91 mm. in diameter, and the diameter of the oil-globule ranged from 0·16 to 0·17 mm. In August the dimensions were 0·78 to 0·84 mm. for eggs and 0·15 to 0·17 for oil-globule, and a newly hatched larva was 2·02 mm. in length. The Heligoland eggs had a diameter of 0·755 to 0·912 and an oil-globule from 0·141 to 0·189 mm. in diameter, while the length of newly hatched larvae varied from 2·26 to 2·90 mm.

The dimensions of my specimens were as follows:—

Diameter of egg . .	0·80, 0·78 × 0·79,	0·81 × 0·84,	0·82.
,, ,, oil-globule	0·145, 0·145	0·165	0·157.

Two of them were ovoidal. The yolk is homogeneous, and the oil-globule is colourless. Just before the formation of the caudal rudiment, the head and body are liberally covered with medium-sized, black chromatophores, and yellow is making its appearance along the sides of the embryo. On the yolk-sac there is pigment of both colours, which is most dense in the postero-ventral region, a feature becoming more strongly marked as development proceeds. In the two larger specimens there are black and yellow chromatophores over the oil-globule, but they are absent from here in the two smaller eggs. Although precautions were taken to keep the temperature low by standing the jars containing ova in circulating tank-water, the eggs became infested by infusoria, whose presence is a usual accompaniment to unhealthy conditions. Development proceeded apace, however, and the next day the free caudal region had grown around the yolk, so as to almost meet the head. The bright yellow pigment of the embryo is now visible to the naked eye. It occurs in large dendritic chromatophores, which ramify and intermingle so as to produce a diffuse colouration over the whole of the pre-anal part of the trunk, and appears especially dense about the anus. There is a further band-like mass of yellow about the mid-post-anal region, and an aggregation of similar chromatophores on the yolk-sac, between the oil-globule and its posterior contour. In one specimen (diameter ·82 mm.) the oil-globule, at this stage, has a dark and smoky appearance, and is densely pigmented. In another specimen no pigment is seen over the oil-globule, and the periblastic pellicle, which is generally quite apparent at this stage, showing an interspace between it and the contained oil-globule, is not distinguishable. The epidermis of embryo and yolk-sac is covered with tiny tubercles, doubtless of pathological origin. Next day the larva had hatched out but was distinctly moribund, and died almost immediately. The total length is 2·16 mm., and it measures 1·00 mm. from snout to anus. The head projects rather considerably over the oval-shaped yolk-sac. In two of my larvae the oil-globule was almost in the centre of the yolk-sac, which was observed by Heincke and Ehrenbaum to be the case only in one instance, and may be regarded, therefore, as an abnormal and possibly pathological condition. The small otocysts are situated some distance behind the eyes. There is a slight swelling in the tubular gut above the pectoral region and the rectum ends blindly immediately behind the postero-dorsal edge of the yolk-sac. The pigmentation, which is on a generous scale, is very characteristic. Inter-ramifying yellow chromatophores form a diffuse mass of colour over the posterior part of the yolk-sac, and practically over the whole of the pre-anal part of the trunk and head, extending a little beyond the anus. Then comes a clear space followed by a band of yellow somewhat behind the mid-post-anal point. The much less conspicuous black pigment in small chromatophores which when relaxed show fine dendritic outgrowths, occurs chiefly on the dorsum in the pre-anal region and, less densely, on the head and sides. Post-anally there are about half a dozen chromatophores along each of the dorsal and ventral contours, extending further posteriorly than the yellow pigment, although the extreme end of the tail is pigmentless for about ·25 mm. Black chromatophores are associated with yellow in the posterior hemisphere of the yolk-sac. The unpaired fins are pigmentless, except for a touch of yellow near the origin of the dorsal fin, immediately behind the otic region.

Apart from its peculiar colouring the larva has the unmistakable gadoid form. The dorsal fin membrane arises over the occipital region, reaches its greatest width above the anus, and thence tapers gradually to the caudal extremity; and similarly the greatest width of the anal fin is immediately below the anus.

On 2nd July, in a surface tow-netting 1¼ miles N. by W. of the Eddystone, an egg was taken which may possibly be identified with this species. Its diameter was ·86 mm., and its single oil-globule measured ·18 mm. The yolk was unsegmented. Just before the outgrowth of the caudal rudiment the body was abundantly besprinkled with faint dark chromatophores. The body appeared relatively wide. Next morning the larva showed a short caudal rudiment and much increase of pigment, which is now canary-yellow as well as black. Roundish chromatophores are fairly generally distributed over the anterior part of the body, but the black appears to be mostly dorsal and the yellow ventral. Post-anally the pigment is less dense. The pellicle of the oil-globule, which has a rough, wrinkled, and rather dark appearance, bears many rounded chromatophores of both colours, rather larger than those on the embryo and constitutes the most conspicuous feature of the ovum. There are a few fine, chiefly yellow chromatophores in the dorsal part of the yolk-sac. The otocysts are relatively small and the rudimentary pectoral fins appear as narrow flaps.

Clupea sprattus. Sprat.

This egg was the commonest of those belonging to food-fishes which occurred in my samples. It was found almost continuously from the middle of February to the middle of June, after which time until 12th July it appeared with less frequency; which may, however, be largely due to the fact that in the summer months most of my plankton was collected from the open sea, while the sprat appears to favour the close vicinity of Plymouth Sound or Cawsand Bay as a spawning locality in the warmer months, although not in winter and early spring. Very many eggs were taken in the young-fish trawl in June and July. The eggs, which are very characteristic from their segmented yolk, had an average diameter of 1·031 mm. for February–March, 0·973 mm. for April–May, and 0·912 for June–July. The pelagic larvae, which will be treated at greater length in a subsequent paper, were most abundant in May and June.

Clupea pilchardus. Pilchard.

My first pilchard eggs were taken on 8th April, 7 miles S.W. of the Eddystone, when several occurred in the tow-nettings. The diameter ranged from 1·63 mm. to 1·84 mm., and that of the oil-globule from 0·15 to 0·16 mm. The next specimen (of 1·6 mm. and 0·145 mm. oil-globule) was found in a young-fish trawl haul taken near the Eddystone on 26th August. More surprising was the occurrence of three eggs in a tow-netting taken inside the Sound on the 14th September. These had diameters of 1·46, 1·52, and 1·62 mm., and oil-globules of 0·145, 0·155, and 0·14 respectively. A newly hatched larva from one of them, measured after being killed in dilute formalin, had a length of 3·8 mm. I may also mention that I have found numerous pilchard eggs in samples of plankton taken in the young-fish trawl in September, 1906, on the Rame-Eddystone Grounds.

As Cunningham (**4**a, p. 44, and **4**d, p. 154) has pointed out, pilchards spawn far out at sea, and it is doubtless due to the fewness of my tow-net samples from the open-sea areas that such a small number of pilchard eggs have come under my observation this season. I may mention in passing that the pilchard fishery season in 1909 has been a decided failure in the Plymouth district as off the Cornish coast, the shoals having kept out in mid-Channel 20 miles or more from the coast, and therefore out of reach of the usual fishing craft. It should be remembered that the great majority of pilchards caught by Plymouth drifters are not spawning fish, the usual shoreward movement of this species in summer and early autumn being apparently a feeding migration. It is hardly relevant to the present subject to discuss the possible causes of the unusual distribution in 1909, nor is there completely satisfactory evidence available. We may, however, assume that the distribution of the spawners which appear to lie outside the main summer shoals may show some variation in relation to the movements of the latter. My collections certainly sampled only the fringe of the great mass of ova spawned, or those which drifted landward with the tide and currents.

B. DEMERSAL EGGS.

Labrus ? mixtus, L.

Eggs which in all probability belong to *Labrus mixtus* were found deposited among a mass of *Chondrus crispus* in a rock-pool on Wembury Reef on 17th June. The mode of occurrence is very similar to what has been described by Matthews for *Labrus maculatus* (**17**), and my first idea was that this was the species to which the "nest" belonged, as it is the most common wrasse in the locality, which could with any certainty be regarded as the parent fish. The smaller size of the eggs, however, and certain differences exhibited by the hatched-out larvae, led me to conclude that this was not a species identical with that described by Matthews, though certainly a closely related form. Of the other wrasses (having unknown ova and larvae) which are known to occur here—*Labrus mixtus*, *Crenilabrus melops*, and *Centrolabrus exoletus*—the first is the form to which every probability points as the parent of these eggs. It is the one other species known to form a nest similar to that of *L. maculatus* (**18**, Vol. III, p. 102), and the size of the eggs is also most in agreement with this parentage. Ripe ova from *Crenilabrus melops* have been described by Holt (**11a**, p. 450) as spherical and having a diameter of 0·78 mm. *Crenilabrus exoletus*, of whose eggs I have no knowledge, is an exceedingly small fish, and is not at all likely to produce ova as large as my specimens. It is moreover a more deep-water form, and is not known to construct a nest between tide-marks.

My specimens had a spherical or somewhat ovoid shape and a thick strong capsule. Five which were measured had the following dimensions—0·92, 0·94, 0·94, 0·90 × 0·94 and 1·08 × 0·86 mm. When first observed on the 17th June the embryonic body with well-marked myomeres had formed, but no caudal outgrowth had appeared. There was a large Küpfer's vesicle. No pigment was visible. The yolk was pale buff-coloured and devoid of any oil-globule. Four days later they have reached the final stage of embryonic development (Fig. 4). The yolk is much reduced, its diameter being about four-sevenths that of the egg-capsule, and the caudal extremity has grown around so that its tip in some cases overlies the auditory region. The yolk is ochreous-yellow and shows a number of small vesicles in the mid-ventral part. In the eyes there is black pigment through which shine golden tints. The body is bestrewn with black chromatophores for about two-thirds of its length, and posterior to this there are some along the dorsal and ventral contours, but the posterior extremity is unpigmented. Yellow chromatophores occur on the anterior part of the body. The yolk-sac shows a few round black pigment spots and many yellow ones. The pectoral fins appear as semicircular flaps near the posterior edge of the yolk-sac. Small bean-shaped otocysts occur at a distance behind the eyes about equal to the diameter of the lens. Fig. 8 depicts a slightly earlier stage.

Two larvae (Fig. 8) measured within a few hours of hatching were 3·26 and 3·28 mm. in length, the pre-anal lengths being 1·80 and 1·76 mm. respectively. The yolk-sac is relatively small, and its contents are clear and almost colourless. The head is rounded; the anus post-median. The dorsal fin membrane arises above the mid-brain and is widest above the anus. There is a well-marked pre-anal fin. The whole of the larval fin membrane has a minute vesicular structure, which is probably a mark of ill-health. Embryonic rays can be seen in the caudal region. The notochord has two layers of cells at least in its posterior part. The pectoral fins are well developed. The body is richly pigmented with black and yellow chromatophores, but the posterior third is conspicuously bare, except for a line of black chromatophores along the ventral contour, while black pigment is lacking above the mid-brain. The sides of the body from the occipital region to a short distance beyond the anus are almost uniformly coloured with round, stellate, black chromatophores about four or five deep. These are most closely set along the dorsal contour, and are more densely distributed above and posterior to the anus than above the yolk-sac. They are not uniformly distributed in the body segments as described by Matthews for *L. maculatus*, but except for the posterior continuation of the ventral line, as above-mentioned, and for the presence of black chromatophores over the sides of the gut, the distribution and abundance of black pigment on the body show much agreement with his specimen. The largest black chromatophores of all are to be seen on the yolk-sac. A group of about five to eight large, but not very intense, chromatophores occurs in the anal fin, immediately behind the anus; otherwise, except for outgrowths from pigment cells along the posterior ventral body margin, the larval fin membranes are entirely free from black pigment (see Figs. 8 and 8a). Yellow pigment is regularly interspersed with black along the sides of the trunk, but is absent over the sides of the gut. There are a few yellow chromatophores on the head, and a single isolated one near the margin of the anal fin, about half-way between the anus and the posterior end of the notochord. Another specimen which I examined showed a less uniform distribution of black pigment on the side of the trunk in the pre-anal region, the chromatophores tending to concentrate along the dorsal contour and above the gut. On the second day the larva had a length of 3·48 mm., the increase being practically entirely post-anal. At this point I made detailed measurements, so as to compare with Matthews' dimensions for *L. maculatus*, which I give side by side below:—

	My specimen.		Matthews' *L. maculatus.*
Tip of jaw to front of eye . .	·12 mm.	...	·10
,, ,, back ,, . .	·39 ,,	...	·37
,, ,, front of ear . .	·42 ,,	...	·41
,, ,, centre of heart . .	ca. ·54 ,,	...	·47
,, ,, end of pigmentation .	2·2 ,,	(main pigmentation)	2·48
Total length	3·48 ,,	...	3,80

I also noted that my larva was distinctly more slender in dorsal view than Matthews' *L. maculatus* (*op. cit.*, Pl. XI).

The pigmentation is in general the same on the second day as on the first, but the post-anal pigment in the anal fin has slightly increased. With the total absorption of the yolk, which has taken place on the fourth day, a still further increase of this pigment is seen, the group of chromatophores behind the anus now numbering fourteen or fifteen; and there is a further extension of pigment from the ventral edge of the trunk to the proximal margin of the anal and pre-anal fin membranes. The embryonic fin-rays, in both the dorsal and ventral parts of the caudal region of the larval fin membrane, are now very evident. A specimen at this stage, after killing in dilute formalin, measured 3·5 mm.

Blennius pholis, L. The Shanny.

It is somewhat surprising that the earliest stages of this common blenny should have remained unknown for so long. McIntosh (**14**g) has published some observations upon eggs deposited in captivity. These were circular in outline, oblate spheroidal in lateral view, and each had a faintly pinkish attachment disc. The diameter was 1·181 to 1·219 mm., the vertical diameter being 0·763 and the height of the attachment rim 0·305 mm. He describes the yolk colour as dull pinkish or faint salmon and in certain lights having a dull brownish appearance.

On June 4th some eggs of *Blennius pholis* accompanied by the parent fish were taken on a stone on the Breakwater rocks. In shape they were ovoid with flattened underside (Fig. 3). The length of the capsule was 1·6 mm., the vertical height just above 1 mm. (with the attachment disc ca. 1·4 mm.). When observed they were at the last stage of embryonic development, the black eyes of the embryo rendering them very conspicuous. The yolk was of a light brown colour. The newly hatched larva (Fig. 6) is of large size—about 4·4 mm. total length and 1·8 mm. from snout to anus. Its very broad and somewhat square head gives it a tadpole-like appearance. There is a striking absence of post-anal pigment. A most conspicuous feature is the pair of large fan-like and heavily pigmented pectoral fins. These are marked with large, black and yellowish brown chromatophores, the former disposed in radial lines, the latter being most concentrated in the basal region and absent from the distal margin. Other black pigment occurs in the eyes, under the mandible where three stellate chromatophores are disposed symmetrically in triangular form, on the neck region as a single pigment spot, and in the peritoneum where there is a short double row of chromatophores. The yolk-sac, protruding on each side, has a yellowish brown tint; there are pale yellow chromatophores on the head and similar pigment, but of more intensity, in the pectoral region. The thickness and opacity of the head causes the otocysts to be hardly visible. The course of the red blood corpuscles along the circulatory system from the yolk to the body of the larva can be very easily seen.

Gobius paganellus, Gm. L.

Some eggs, together with a fish of this species, were taken on a stone between tide-marks on the shore of Rum Bay on 3rd June. The ova have been described by Holt and Byrne (**13**, p. 46) as regularly fusiform in shape, about twice as high as wide and with rather sharply pointed ends; by which characters they are distinguishable from the eggs of all other British species of goby. The above-mentioned authors give 1·84 to 1·9 mm. as the length. An egg which I measured at a late embryo stage was 2·3 mm. long and 0·74 mm. wide, while a second was slightly longer. The yolk was of a greyish brown colour and was darkened by the presence of many small oil-globules. When the embryo is advanced in development, the eyes become extremely conspicuous, showing abundant black pigment and a bronze-green lustre. The oval swim-bladder with strongly marked dendritic chromatophores and some yellow pigment over the dorsal side of it is plainly visible. This is the only really conspicuous pigment on the embryo at this stage. The large bean-shaped otocysts contain relatively small otoliths.

The newly hatched larva (Fig. 7) has a total length of 4·8 mm., the pre-anal length being 2·2 mm., so that the anus is just anterior to the median. The head is somewhat rounded and the lower jaw slightly projecting. The large, oval swim-bladder is a conspicuous object midway between otocysts and anus. The gut is straight and has a slight ventral dilation below the hinder end of the swim-bladder. As in the embryo, the most conspicuous pigment is above the swim-bladder (black and yellow) and in the eyes, which are black with blue, green, and gold tints. There is a continuous row of black chromatophores from the throat to the anus along the ventral contour, the largest one with well-marked dendritic rays being below the above-mentioned bulge in the gut; the terminal one below the anus is also very pronounced. Except above the swim-bladder there is no peritoneal pigment nor any other chromatophores anterior to the anus. Post-anal ventral pigment consists of a discontinuous series of black dendritic chromatophores (about six or less in number) extending to the hypural region, the largest of which is situated in the centre of the post-anal part and has yellow associated with it. Dorsally there is only one, relatively small, black chromatophore, accompanied by yellow, opposite the large mid-post-anal one of the ventral row. This dorsal pigment is often lacking entirely. The notochord is unicolumnar. The pectoral fins are rather large, extending to about the middle of the swim-bladder. The embryonic dorsal fin arises above their base. There is a short pre-anal fin commencing below the gastric dilation. A brownish gall-bladder is visible. At the age of five or six days the ventral post-anal pigment appears to have concentrated itself more in the central part of the post-anal region and in the hypural part, but otherwise the pigment remains as in the early stages. Embryonic fin-rays have developed in the position of the second dorsal and the anal fin and a hypural lobe has formed.

Lepadogaster bimaculatus, Donov. Doubly spotted Sucker.

The eggs and newly hatched larva of this species have previously been described by Holt (**11a**, p. 447, Pl. XLVII, Figs. 1 to 7), but as all my observations have shown certain differences from the specimens he describes it will be well to give some details from my records.

My observations were first undertaken chiefly with a view to getting a knowledge of the early post-larval forms for the purpose of comparison with pelagic Lepadogaster fry taken in our young-fish trawl. The following are brief particulars as to the capture of specimens of the eggs of this species which came under my notice in the summer of 1909:—

Date.	Locality.	Instrument of capture.	Other remarks.
8th June, 1909	Queen's Ground .	Dredge . .	Eggs encrusting inside of a *Tellina* valve. Greatest horizontal axes of egg-capsule, 1·4 × 1·2 mm.
16th June, 1909	Rame-Eddystone Ground	Otter trawl .	Eggs in *Lutraria* valve with parent fish. Greatest horizontal dimensions, 1·4 × 1·16 mm.; height, 0·70 mm.
5th July, 1909	Hand Deeps .	Dredge . .	Several batches of eggs with parent fish in valves of *Pecten opercularis* and *Lutraria*.
13th July, 1909	Hand Deeps .	Dredge . .	Eggs in *Pecten opercularis* valve. Accompanying fish a female.

On 14th June a female *Lepadogaster bimaculatus*, with spent, flaccid and membranous ovaries, was taken in a *Lutraria* valve, within which a batch of eggs *had* been deposited, but which had disappeared, leaving traces of their former presence in the form of oval impressions. The nudibranch *Calma glaucoides* and a batch of its eggs were also occupying the valve, and it seems probable, if not certain, that the fish-eggs had been devoured by the nudibranch, which has been recorded as commonly occurring associated with Goby and Blenny eggs, and varying in colour so as to resemble the eggs which it apparently preys upon.*

Quite recently—viz. on 17th February, 1910, and after this paper was in manuscript—I have secured an early batch of *Lepadogaster bimaculatus* eggs. On this occasion I took particular care to examine the accompanying parent fish so as to make sure of its identity as distinct from *L. microcephalus*, a closely similar species first distinguished by Brook,† whose description, however, I have not yet been able to see. Ehrenbaum (5b, p. 121) gives as the distinctive fin-ray formula for *L. microcephalus* D = 5, A = 6, C = 17–19; while Day gives for *L. bimaculatus* D = 5–7, A = 4–6, C = 12. My specimen has clearly six dorsal fin-rays and not more than four or five anal fin-rays, which precludes *L. microcephalus*, while in its general appearance it resembled the common two-spotted sucker, *L. bimaculatus*. It was not possible to count the caudal rays, as it was desired to keep the specimen alive and uninjured. Two of the eggs had the following dimensions:—Oval outline of egg-capsule, as seen from above, measured in one case 1·44 × 1·24 mm. and in the other 1·54 × 1·22 mm. The height of the capsule was respectively 0·62 and 0·70 mm. The sizes closely approximate to those noted the previous summer, and in following through the development from pre-embryonic to larval stages, the characters proved to be identical, save for very slight variation in pigmentation.

The ovoidal inferiorly truncated egg-capsule and its peculiar basal attachment disc and filaments have been minutely described by Holt (*op. cit.*). I noted that as a rule the eggs in one batch showed several stages of development, indicating that they were deposited intermittently. In the earliest stages the finely granular yolk is quite colourless and translucent, and carries a single oil-globule of about 0·25 to 0·28 mm. diameter, which has a slightly darker appearance than the yolk and is at first the most conspicuous content of the egg. The embryo almost invariably occupies a horizontal position in the egg. Black pigment appears on the body soon after the outgrowth of the caudal rudiment, and soon forms a dense and continuous line along the ventro-lateral region from immediately behind the pectoral fins to within a short distance of the caudal tip. Anteriorly pigment is sparse, only a few chromatophores occurring about the neck region and shortly afterwards on the eyes. Yellow chromatophores (bright lemon-yellow by reflected light, brownish by transmitted light) next appear on the sides of the embryo above the dense line of black pigment above-mentioned (see Fig. 5). At about the same time black chromatophores frequently appear along the dorsal surface of the yolk-sac adjacent to the trunk of the embryo. The circulatory fluid is now of a red colour, which is plainly visible at the heart systole. Before the appearance of the yellow pigment the blood was colourless, but even then its circulation could be observed in vessels from the yolk-sac, and in the aorta and main arteries of the head. A day or two after the appearance of yellow, an increase takes place in the amount of black pigment, a double ventro-lateral line being formed on each side with the inferior pair, which are the more distinctly marked, coming together at the anus. A sprinkling of lateral chromatophores next appears, and the eyes become so dark as to be conspicuous to the naked eye. The only other black pigment in the anterior region is a pair of lines converging towards the occiput from the posterior lateral part of the yolk-sac. The yolk-sac and occipital region are covered with diffuse pale yellow.

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* See *Journ. M.B.A.*, N.S., Vol. VII, p. 280.

† Brook, G., *Proc. Roy. Phys. Soc. Edin.*, Vol. X, Pt. 1, p. 166.

The newly hatched larva (see Fig. 16) has a length of 4·26 mm., of which about five-eighths is pre-anal. The remnant of yolk is relatively small, as is usual with larvae from demersal eggs, and bulges out on each side of the larva. A small oval swim-bladder is present. Rounded, stellate, black chromatophores uniformly beset the sides of the trunk in fairly regular lines, which are about four deep transversely in the pre-anal and about three deep in the post-anal region. These are larger in the anterior part of the body than posteriorly. There are similar lines of yellow chromatophores (pale lemon coloured by reflected, brownish by transmitted light) slightly less numerous and at greater interval. These are more densely distributed posteriorly than anteriorly. The most dorsal row of chromatophores are yellow and these are of a larger size and greater deneness than the others. Over the straight intestine yellow pigment is generally sparse and sometimes quite lacking. The posterior portion of the tail, for about 1 mm., is quite unpigmented, as is also the median strip along the whole dorsum. The only pigment in the larval fins consists of a small group of about three to five black chromatophores in the anal fin immediately behind the anus. The snout is rounded. The large otocysts are situated immediately behind the eyes. The dorsal fin arises a little behind the level of the posterior edge of the yolk-sac. Tiny epidermal vesicles densely cover the embryonic fins, except along the margin of its most posterior part.

Two post-larvae, measured soon after the yolk had been absorbed, had lengths of 4·8 and 4·9 mm. The jaws had appreciably developed, especially the mandible, so that the earlier sub-terminal position of the mouth was changed; but otherwise they resembled the newly hatched individuals. The differences between my specimens and those recorded by Holt are in size and pigmentation. His newly hatched larvae measured 2·97 to 3·15 mm., and apparently had no yellow pigment (*op. cit.*, p. 448). His eggs were slightly smaller than mine, having a length of 1·37 mm., a breadth of 1·08 mm., and a height of 0·68 mm., and the oil-globule measured 0·24 mm. Guitel (**9**, Pl. XXV, Fig. 8) figures an early post-larval *L. bimaculatus* of uncertain age, which is about 4·6 mm. long and is pigmented somewhat similarly to those I have examined, except that the superior line of yellow chromatophores is not clearly shown on the side and the black chromatophores are lacking in the anal fin. As regards Holt's specimen, if it is the same species as those I have examined, I can only suggest that it may have been an abnormal specimen, possibly prematurely hatched under unfavourable conditions.

Lepadogaster gouani, Lacep. Cornish Sucker.

On the 17th June several batches of the eggs of this species were taken on the underside of flat stones between tide-marks on Wembury Reef. The parent fish was always to be found near, and generally close alongside the eggs, which cover several square inches of the stone with a closely applied layer. Two, three, or four stages of development may be seen in one batch of eggs. In the earliest stages the yolk is bright amber coloured, which renders the mass of ova an object of much conspicuousness and beauty. Subsequently the colours become gradually darker to orange, and finally, when the embryo is advanced, they have in the mass an olive-green appearance. The egg-capsule is oval-shaped with flattened base, of length 1·90 mm. and breadth 1·56 mm. The yolk contains a large oil-globule of 0·34 mm. diameter.

When a short caudal rudiment is developed, the embryo has a general reddish tint, and shows many stellate black chromatophores over the greater part of the body, the posterior portion, however, being unpigmented. The movement of pale reddish circulatory fluid along the vessels from the yolk to the heart is plainly visible.

The newly hatched larva has a length of 5·1 mm., the anus is post-median, and the yellowish yolk-sac protrudes on either side of the anterior abdominal region. The straight gut shows internal convolutions and a yellowish green gall-bladder is visible. The dorsal embryonic fin arises in the occipital region, the caudal part of it being spatulate. The head is rounded and the mouth terminal, the otocysts situated immediately behind the eyes. Pigmentation is extremely rich. Black chromatophores are the most abundant, covering the sides of the trunk and gut in closely set and fairly regular longitudinal lines. The largest chromatophores are those on the dorsal surface of the head, and those along the dorsal contour are the largest and most closely set of those on the trunk. Post-anally the number of chromatophores counted transversely is four or five. About 0·8 mm. from the posterior end of the notochord, the greater part of the pigmentation ceases, but there may be a few small pigment spots over the notochord behind this point. Along the anal fin there is a line of black chromatophores, extending from immediately behind the anus to the hypural area. Mid-laterally, where the black pigment is least dense, there is an irregular line of about seven large lemon-yellow chromatophores, extending from the level of the posterior edge of the yolk-sac to a little behind the anus. Between all the other chromatophores are numerous small orange-coloured ones, with a relatively large, clear, central space, which gives them the appearance of small rings. Most of the black and yellow chromatophores also have the form of radiations from a central unpigmented spot. Small, round or stellate chromatophores of a pure red colour occur on the ventral surface of the abdomen anterior to the anus. There is no yellow or orange pigment over the sides of the abdomen, but only black, and it is perhaps worthy of note to mention that the black chromatophores of this region appear to have a different structure from those over the rest of the body, the centre of the spot in this case being pigmented instead of clear. The proximal part of the median fin membrane shows the same minute vesicular structure as was seen in *L. bimaculatus*, but the vesiculation does not extend so near to the margin.

A slightly older larva measured 5·7 mm., and was 3·2 mm. from snout to anus. At four or five days old the length is 6·3 mm., the pre-anal portion being 3·4 mm. A hypural thickening is visible. The pigmentation at this age is practically the same as in the newly hatched form, except for an increase of red pigment on the inferior parts of the body. A larva in which the yolk has been entirely absorbed shows small red chromatophores on the ventral surface of the lower jaw, on the ventro-lateral part of the opercular region, on the ventral and ventro-lateral surface of the abdomen and over the basal part of the large pectoral fins.

The pelagic post-larval stages of *L. gouani* can be easily distinguished from those of *L. bimaculatus* by their larger size at the same point in development, and by the distinctiveness of their coloured pigment. In preserved specimens in which all but the black chromatophores have disappeared, one can at once distinguish *L. bimaculatus* by its relatively wide unpigmented strip along the dorsum, only a very narrow line being left clear between the pair of dorsal lines of chromatophores in *L. gouani*. There is also a difference in the distribution of pigment spots in the anal fin. As is to be expected, however, I have never met with the young stages of *L. gouani* in plankton taken away from the vicinity of the shore, while post-larval *L. bimaculatus* may be taken some miles out at sea.

Zeus faber, L. John Dory.

On 31st August five good-sized dories were taken in the otter-trawl 2½ miles S.W. of Rame Head. One of these was an unripe male, and three were females, which had recently spawned. From the ovary of one of the latter I obtained a dead egg, which had already undergone degeneration and was opaque and pale greenish in colour. The fifth proved to be a female approaching ripeness, and from the ovary of this I obtained a few apparently ripe eggs, which occurred free in the lumen. The great majority of the ova, however, were still small and opaque, and contained firmly in the ovigerous lamellae. The ripe eggs are large and contain a relatively small greenish yellow oil-globule (Fig. 1). The rather thick egg-capsule is marked by conspicuous corrugations, which appear to be intertwined in a very irregular manner, and also by finer striations, the former of which are doubtless merely characteristic of the ovarian condition and caused by contact with vascular tissue in the ovary. The yolk is colourless and homogeneous, the ripe egg being translucent and glassy, but not of that clear transparency which is seen in all pelagic eggs, and by transmitted light it has a slightly brownish tint, which is apparently produced by the interference of the corrugated capsule with the free transmission of light rays.

The dimensions taken from four eggs are as follows:—

	Diameter of Egg.		Diameter of Oil-globule.
(1)	2·04 × 2·14 mm.	...	0·44 mm.
(2)	2·03 ,,	...	0·44 ,,
(3)	2·05 ,,	...	0·28 and 0·22 mm.
(4)	1·90 ,,	...	0·43 mm.

In the third egg measured the oil was contained in two separate globules, which is commonly the case in an unfertilized egg. The fourth specimen measured was apparently not quite ripe.

The eggs sink in sea-water of specific gravity 1·026. Fulton (**8**), from minute observations made upon the ripening ovarian ova of a dory caught in April, concluded that the mature eggs would prove to be large, contain one or more oil-globules and be demersal; which conclusions are confirmed by the character of my ripe eggs. Their demersal nature was indicated, even at that stage, by the comparatively dense fibrous nature of the tissue of the stroma and the follicle, by the presence of a well-defined double layer, by the character of the yolk, and by the general hardness and resistance to pressure, all these features being in contrast with ovarian pelagic eggs. One of the largest specimens examined by Fulton from the ovarian stroma measured 1·39 mm. in diameter and contained two groups of three and four oil-globules. Some other slightly smaller eggs contained a prominent straw-coloured oil-globule: thus in an egg of 1·02 mm. diameter the oil-globule measured 0·25 mm. All these were quite opaque and white by reflected light and still contained in the follicular investment.

Holt has recorded the capture of ripe females off the west coast of Ireland in July and August, and one spent in June.* Cunningham (**4**g, p. 322) also has found ripe females in August at Plymouth. The demersal character of the eggs and the relatively deep-water habitat of the spawning fishes are sufficient to account for the present lack of knowledge of embryonic development. The youngest post-larval stages yet recorded are those described by Schmidt (**21**d) from four specimens (7¾ mm. to 19 mm. long) taken by the *Thor* in August and September, 1906 (three from various parts of the Channel and one from the Bay of Biscay); to which must be added one specimen of 14 mm. taken by the *Oithona's* young-fish trawl off Plymouth Sound on the 17th of September in the same year.

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EXPLANATION OF PLATES I AND II,

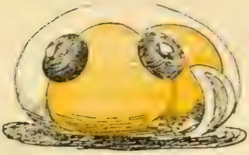
Illustrating Mr. A. E. Hefford's "Notes on Teleostean Ova and Larvae observed at Plymouth in Spring and Summer, 1909."

PLATE I.

Fig. 1. *Zeus faber*, ripe ovarian egg ; diameter, ca. 2·09 mm.
Fig. 2. *Zeugopterus punctatus*, pelagic egg ; diameter, 0·99 mm.
Fig. 3. Egg of *Blennius pholis*, lateral view ; dimensions, 1·8 × 1·2 × 0·8 mm.
Fig. 4. Egg of *Labrus mixtus ;* diameter, 0·94 mm.
Fig. 5. Egg of *Lepadogaster bimaculatus ;* dimensions, 1·44 × 1·24 × 0·62 mm.
Fig. 6. *Blennius pholis*, newly hatched larva ; length, ca. 4·4 mm.
Fig. 7. *Gobius paganellus*, newly hatched larva ; length, 4·8 mm.
Fig. 8. *Labrus mixtus*, newly hatched larva ; length, 3·26 mm.
Fig. 8a. *Labrus mixtus*, sketch showing arrangement of anterior dorsal black pigment.
Fig. 9. *Zeugopterus punctatus*, newly hatched larva ; length 2·90 mm.
Fig. 10. *Z. punctatus*, larva ca. 3 days old.

PLATE II.

Fig. 11. *Solea lascaris*, newly hatched larva ; length, 3·46 mm.
Fig. 12. *S. lascaris*, larva 4 or 5 days old.
Fig. 13. *Serranus cabrilla*, early larva ; length, 2·30 mm.
Fig. 14. *Onos? tricirratus*, Bl., newly hatched larva ; length, 2·32 mm.
Fig. 15. "*Onos*, species B" (? or abnormal form), newly hatched larva ; length, 1·84 mm.
Fig. 16. *Lepadogaster bimaculatus*, newly hatched larva ; length, 4·26 mm.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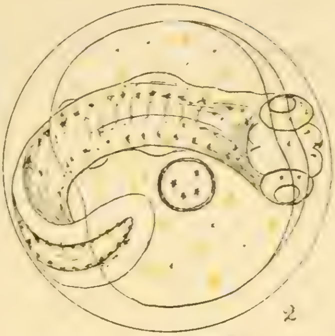
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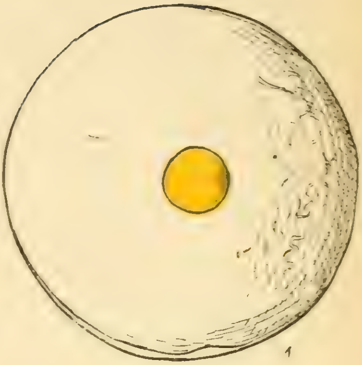
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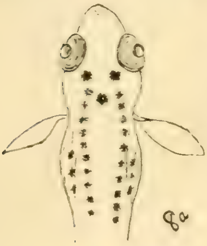
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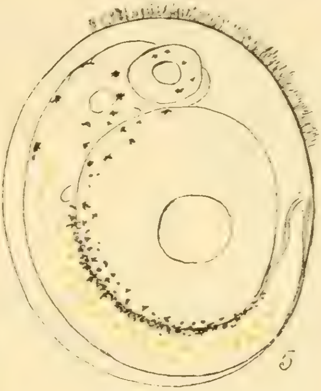
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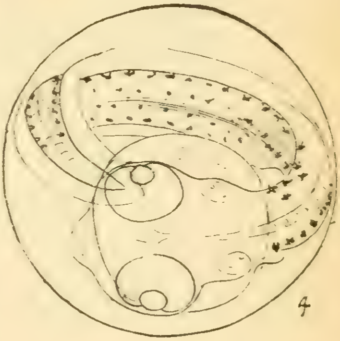
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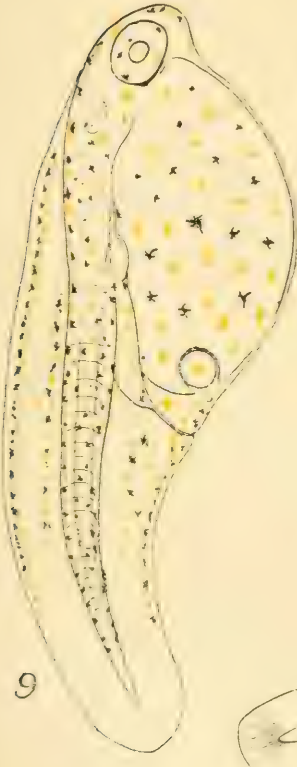
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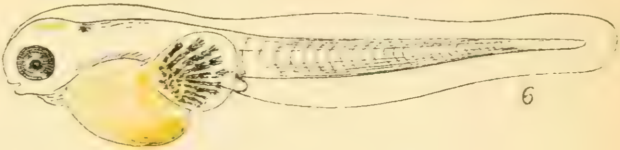
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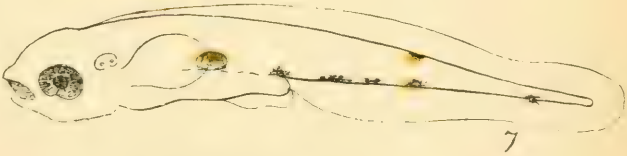
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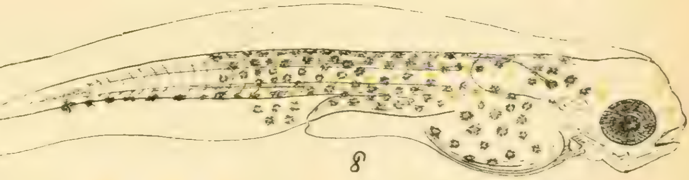
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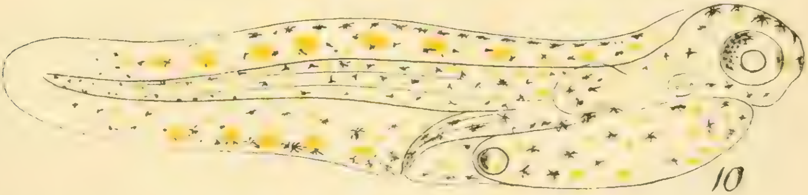
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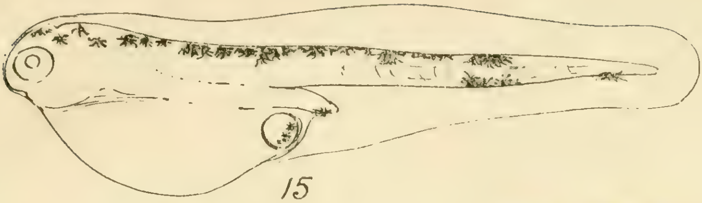
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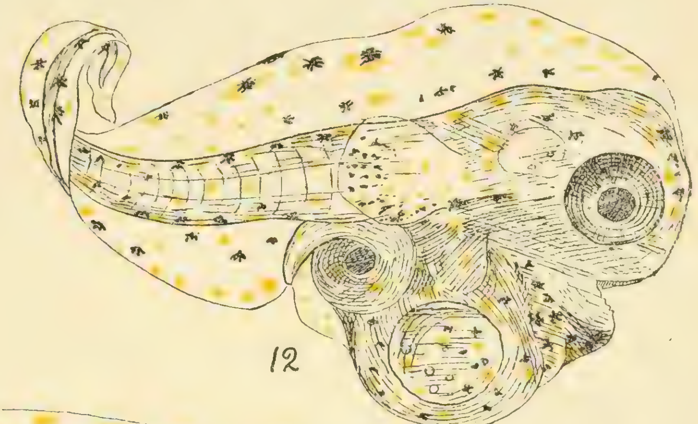
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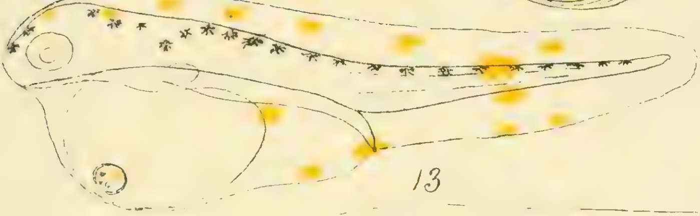
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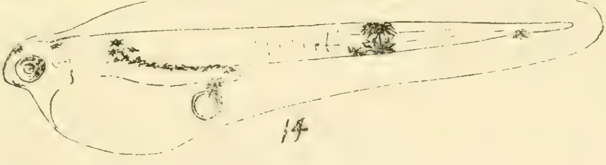
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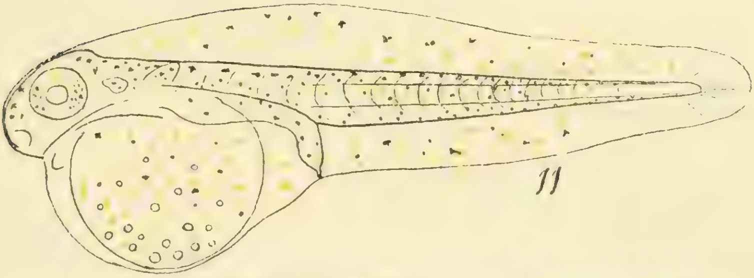
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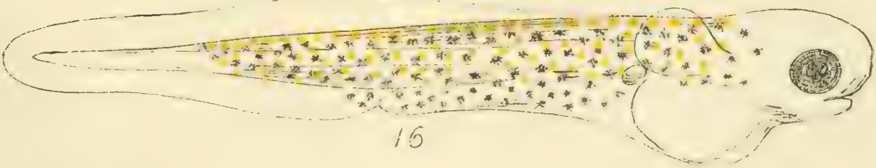
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Notes on the Littoral Polychæta of Torquay (Part III).

By

Major E. V. Elwes.

Aphroditidæ.

A SYNOPSIS of the Aphroditidæ of the English Channel by Mr. T. V. Hodgson is given in the *Journal Marine Biological Association*, Vol. VI, No. 2, 1900.

APHRODITA ACULEATA, Lin. *McIntosh, Mon. Brit. Ann.*, Vol. II, p. 247.

This species is sometimes found in some numbers, thrown up on the shore after heavy weather, especially at Anstey Cove and Tor Abbey Sands. It is recognized by the fishermen as a "curiosity."

LEPIDONOTUS SQUAMATUS, Lin. *McIntosh, Mon. Brit. Ann.*, Vol. II, p. 274.

Only two or three examples found under stones on Babbacombe beach.

LEPIDONOTUS CLAVA, Mont. *McIntosh, Mon. Brit. Ann.*, Vol. II, p. 280.

Occasionally found on all the beaches. Numerous specimens were found on a large buoy in Torquay Harbour.

LAGISCA FLOCCOSA, Sav. *McIntosh, Mon. Brit. Ann.*, Vol. II, p. 298.

Fairly common under stones.

LAGISCA EXTENUATA, Gr. *McIntosh, Mon. Brit. Ann.*, Vol. II, p. 307. Hornell, *Fauna of Liverpool Bay*, 1892, p. 136, Pl. XIII, Fig. 8.

Very common in roots of Laminaria and under stones. The scales have the groups of papillæ surrounded by lines as represented by Hornell.

EVARNE IMPAR, Johnst. *McIntosh, Mon. Brit. Ann.*, Vol. II, p. 358.

Rare. Recorded by Gosse from Anstey's Cove.

HARMOTHÖE SPINIFERA, Ehlers. *McIntosh, Mon. Brit. Ann.*, Vol II, p. 327.

One example only.

HALOSYDNA GELATINOSA, M. Sars. *McIntosh, Mon. Brit. Ann.*, Vol. II, p. 384.

One specimen under a stone on Babbacombe beach.

POLYNOE SCOLOPENDRINA, Sav. *McIntosh, Mon. Brit. Ann.*, Vol. II, p. 389.

Not uncommon at Corbyn's Head.

STHENELAIS BOA, Johnst. *McIntosh, Mon. Brit. Ann.*, Vol. II, p. 408.

Not uncommon in the sand at Tor Abbey Sands.

SIGALION MATHILDÆ, Aud. and Edw. *McIntosh, Mon. Brit. Ann.*, Vol. II, p. 427.

This is the only one of the Torquay Aphroditidæ which has not been also recorded from Plymouth. It is fairly common in the sand at Tor Abbey Sands and Livermead.

PHOLOË MINUTA, O. Fabricius. *McIntosh, Mon. Brit. Ann.*, Vol. II, p. 437.

The most numerous of all the Torquay Aphroditidæ, inhabiting especially the Laminaria roots.

Glyceridæ.

GLYCERA CONVOLUTA, Kef. *De St. Joseph, Ann. Sci. Nat. Zool.*, Vol. XVII, 1894, p. 27.

Fairly numerous in Tor Abbey Sands and at Livermead.

GLYCERA LAPIDUM, Qfg. *McIntosh*, "On the British Glyceridæ," *Ann. Nat. Hist.*, S. 7, Vol. XV, p. 39, 1905.

One specimen in the inner harbour of Torquay and one on the Babbacombe beach.

Eunicidæ.

This family is represented at Torquay by five littoral species. For the key to the Eunicidæ of the English Channel the papers by Baron de St. Joseph, entitled "Les Annélides Polychètes des Côtes de Dinard" and "Les Annélides Polychètes des Côtes de France," the "Notes on the British Eunicidæ," by Professor McIntosh, *Annals of Natural History*, Vol. XI, p. 553, 1903, and the *Cambridge Natural History*, Vol. II, have been consulted.

LYSIDICE NINETTA, Aud. and Edw. *Johnst., Catalogue of Worms*, p. 140.

Small specimens thirty to fifty millimetres in length; extremely common amongst Laminarian roots and limestone rocks.

NEMATONEREIS UNICORNIS, Grube. *De St. Joseph, Ann. Sci. Nat.*, V, 1888, p. 207.

Fairly common in the limestone rocks at Babbacombe, but as is the case with the last species it is very rarely perfect.

STAUROCEPHALUS RUBROVITTATUS, Grube. *De St. Joseph, Ann. Sci. Nat.*, V, 1888, p. 235.

One specimen obtained at an unusually low spring tide at Corbyn's Head.

OPHRYOTROCHA PUERILIS, Clpd. and Meczn. *Cambridge Nat. Hist.*, Vol. II, p. 319, Fig. 170.

This little worm is frequently seen on the sides of glass vessels containing roots and pieces of rocks. On one occasion a small aquarium in the museum of the Torquay Natural History Society was found to be swarming with this species.

LUMBRICONEREIS LATREILLI, Aud. and Edw. *De St. Joseph, Ann. Sci. Nat. Zool.*, V, 1898, p. 276.

Three or four in rather coarse gravel on Babbacombe beach.

Sphœrodoridæ.

EPHESIA GRACILIS, Rathke. *De St. Joseph, Ann. Sci. Nat. Zool.*, XVII, 1894, p. 33. *McIntosh, Ann. Nat. Sci.*, S. 8, Vol. II, 1908, p. 528 and 540.

Two or three from Meadfoot beach.

EPHESIA PERIPATUS, Clpd. nee Johnst. *Claparède, Beob. über Anat. und Ent. wirbellosen thiere*, p. 50, *de St. Joseph, Ann. Sci. Nat. Zool.*, XVII, 1894, p. 41.

Two specimens from Corbyn's Head. According to de St. Joseph this species differs from *E. gracilis* by several characters, but he only mentions two, viz. the composite bristles and the absence of the "l'éventail de papilles" below the feet which exists in *E. gracilis.* The bristles of *E. peripatus* of the Torquay examples seem, besides being compound, to be not quite so stout and not so much bulged as those of *E. gracilis.*

Ariciidæ.

ARICIA LATREILLI, Aud. and Edw. *De St. Joseph, Ann. Sci. Nat. Zool.*, XVII, 1894, p. 85.

Several examples were dug up from the sand at Tor Abbey Sands. In this species there are about thirty bristle-bearing segments in the anterior region, while in *A. cuvieri* there are only twenty-one.

Spionidæ.

In preparing the accompanying key to the Spionidæ of the English Channel Mesnil's paper, entitled "Études de Morphologie externe chez les Annélides" and Professor McIntosh's "Notes on the British Spionidæ," *Annals of Nat Hist.*, S. 8, Vol. III, have been consulted.

SCOLECOLEPIS VULGARIS, Johnst. *McIntosh, Annals of Nat. Hist.*, S. 8, Vol. III, 1909, p. 159.

At the west end of Tor Abbey Sands; rare.

SCOLECOLEPIS FULIGINOSA, Clpd. *McIntosh, Annals of Nat. Hist.*, S. 8, Vol. III, 1909, p. 160.

Very numerous at west end of Tor Abbey Sands and at Livermead. In December numbers were found coiled up together under stones.

NERINE CIRRATULUS, Delle Chiaje. *McIntosh, Annals of Nat. Hist.*, S. 8, Vol. III, 1909, p. 158.

Tor Abbey Sands; not numerous.

AONIDES OXYCEPHALA, Sars. *Mesnil, Bull. Sci. France et Belgique*, XXIX, 1896, p. 242.

Numerous in rather foul mud under stones at Livermead.

POLYDORA CILIATA, Johnst. *McIntosh, Annals of Nat. Hist.*, S. 8, Vol. III, p. 169.

Very numerous in the small pools in the limestone boulders on the shore.

POLYDORA FLAVA, Clpd. *McIntosh, Annals of Nat. Hist.*, S. 8, Vol. III, p. 169.

Numerous on rocks and in pools.

SPIOPHANES BOMBYX, Clpd. *McIntosh, Annals of Nat. Hist.*, S. 8, Vol. III, p. 167.

A few specimens at the east end of Tor Abbey Sands. Mesnil remarks that he found this species in company with *Echinocardium cordatum;* this sea urchin is also common on Tor Abbey Sands.

Magelonidæ.

MAGELONA PAPILLICORNIS, Fr. Müller. *McIntosh, Annals of Nat. Hist.*, S. 8, Vol. III, p. 174.

One example at a very low spring tide on Tor Abbey Sands.

Ammocharidæ.

OWENIA FUSIFORMIS, Delle Chiaje. *De St. Joseph, Ann. Sci. Nat. Zool.*, V, 1898, p. 397.

The tubes of this species are very numerous on Tor Abbey Sands; they appear to be loose in the sand, not fixed vertically, as is usual with tube-dwelling annelids in sand. They are largest in the middle, tapering towards both ends, made chiefly of small pieces of shell placed edgeways.

Cirratulidæ.

In the accompanying key to the Cirratulidæ of the Channel the classification of Caullery and Mesnil in *Les formes épitoques et l'evolution des Cirratuliens* is adopted.

AUDOUINIA TENTACULATA, Montagu. *De St. Joseph, Ann. Sci. Nat. Zool.*, XVII, 1894, p. 49.

Numerous at Meadfoot, Hope's Nose, and Tor Abbey Sands in rather foul mud; young ones about 40 mm. in length appear to live in crevices in rocks.

DODECACERIA CONCHARUM, Oersted. *Caullery et Mesnil, Annales de l'Université de Lyon,* Fasc. XXXIX, 1898, p. 11.

Very numerous in the limestone boulders at Babbacombe.

HETEROCIRRUS VIRIDIS, Lang. = *H. flavoviridis*, de St. Joseph. *Caullery et Mesnil, Ann. de l'Université de Lyon,* Fasc. XXXIX, 1898, p. 117.

Found occasionally in small pools in limestone rocks at Babbacombe.

HETEROCIRRUS CAPUT ESOCIS, de St. Joseph. *Caullery et Mesnil, Ann. de l'Université de Lyon,* Fasc. XXXIX, 1898, p. 122.

Two or three examples found in the same localities as the last species. I have not seen any British records of these two species of Heterocirrus.

Terebellidæ.

The accompanying key to the Terebellidæ is founded on the table given by Baron de St. Joseph in "Les Annélides Polychètes des Côtes de Dinard," *Ann. Sci. Nat. Zool.*, XVII, 1894, p. 180.

POLYMNIA NEBULOSA, Montagu. *De St. Joseph, Ann. Sci. Nat. Zool.*, XVII, 1894, p. 219.

Occasional specimens at Corbyn's Head and in rocks between Oddicombe and Babbacombe beaches.

POLYMNIA NESIDENSIS, de St. Joseph. *Ann. Sci. Nat. Zool.*, XVII, 1894, p. 211.

Very common in Laminaria roots, etc.

LANICE CONCHILEGA, Pallas. *De St. Joseph, Ann. Sci. Nat. Zool.*, XVII, 1894, p. 211.

Numerous on Tor Abbey Sands, especially at the east end.

Ampharetidæ.

Melinna adriatica, Marenzeller. *Sitzb. d. k. Akad. Wiss. zu Wien*, LXIX, p. 472.

Two at extreme low water at Livermead amongst Zostera roots.

Maldanidæ.

Clymene œrstedii (?), Clpd. *De St. Joseph, Ann. Sci. Nat. Zool.*, XVII, 1894, p. 137.

On the east side of Tor Abbey Sands; not common.

Leiochone clypeata, de St. Joseph. *Ann. Sci. Nat. Zool.*, XVII, 1894, p. 139.

Numerous at extreme low water in the centre of Tor Abbey Sands.

Capitellidæ.

Notomastus latericeus, Sars. *De St. Joseph, Ann. Sci. Nat.*, XVII, 1894, p. 117.

Under stones, Corbyn's Head and Livermead.

Opheliidæ.

Polyopthalmus pictus, Duj. *De St. Joseph, Ann. Sci. Nat. Zool.*, V, 1898, p. 385.

Common amongst Corallines, etc., in rock pools.

Arenicolidæ.

Arenicola marina, L. *Gamble, Quart. Journ. Micro. Sci.*, XLIII, p. 419.

Common on Tor Abbey Sands.

Arenicola ecaudata, Johnst. *Gamble, Quart. Journ. Micro. Sci.*, XLIII, p. 419.

This species seems to be very different in its habits to *A. marina*; instead of burrowing in soft mud and sand it lies under stones in gravel at Hope's Nose and Babbacombe beach.

Chlorhœmidæ.

Siphonostoma affinis, M. Sars. *De St. Joseph, Ann. Sci. Nat. Zool.*, XVII, 1894, p. 96.

Under stones at Corbyn's Head.

Sabellidæ.

The accompanying key to the Sabellids of the English Channel is founded on the table given by Baron de St. Joseph in "Les Annélides

Polychètes des Côtes de Dinard," *Ann. Sci. Nat. Zool.*, XVII, 1894, p. 248.

SABELLA PAVONINA, Sav. *De St. Joseph, Ann. Sci. Nat. Zool.*, XVII, 1894, p. 267.

I was somewhat surprised to find several examples of this large worm in the inner harbour at Torquay only a few yards from the "Strand." They were living in mud and gravel which could hardly be called clean.

POTAMILLA RENIFORMIS, O. F. Müller. *Soulier, Revision des Annélides de la region de Cette*, p. 120, Fig. 4.

This species is found on the sides of the cave under the men's bathing-place at Petit Tor. This is the cave mentioned by Gosse in the *British Sea Anemones and Corals*, where he found the sea anemones *Halcampa microps* and *Edwardsia carnea.*

POTAMILLA TORELLI, Mgr. *De St. Joseph, Ann. Sci. Nat. Zool.*, XVII, 1894, p. 296.

Common in the small rock pools in the limestone rocks between Oddicombe and Babbacombe beaches.

FABRICIA SABELLA, Ehr. *De St. Joseph, Ann. Sci. Nat. Zool.*, XVII, 1894, p. 319.

A little Sabellid which appears to be referable to this species is very common in the little pools in the rocks at Babbacombe, in company with the last species, *Polydora* and *Dodecaceria.* It lives in small holes in the rocks, with a tube of mud projecting a little from the opening.

ORIA ARMANDI, Clpd. *Soulier, Revision des Annélides de la region de Cette*, 1902, p. 114, Fig. 2.

One specimen from Babbacombe rock pools. As de St. Joseph remarks, the eyes in this species quickly disappear, while in *F. sabella* they are persistent even in Balsam preparations. I have also obtained this species at Newquay, Cornwall.

JASMANEIRA ELEGANS, de St. Joseph. *Ann. Sci. Nat. Zool.*, XVII, 1894, p. 316.

Found occasionally crawling up the sides of glass vessels containing roots of Laminaria and pieces of limestone rock. It was first recorded as a British species by Miss Newbiggin in 1900.

AMPHIGLENA MEDITERRANEA, Clpd. *Soulier, Revision des Annélides de la region de Cette*, p. 109, Fig. 1.

Found under the same conditions as the last species.

Serpulidæ.

In preparing the key to the Serpulids of the English Channel the table given by Baron de St. Joseph in the *Annales des Sciences naturelles Zool.*, XVII, 1894, p. 259, and, for the genus Spirorbis, the papers by Caullery and Mesnil, "Études sur la morphologie, etc., chez les Spirorbes," have been consulted.

SERPULA VERMICULARIS, Lin. *De St. Joseph*, *Ann. Sci. Nat. Zool.*, XVII, 1894, p. 328.

On shells thrown up on the shore at Tor Abbey Sands.

POMATOCEROS TRIQUETER, Lin. *De St. Joseph*, *Ann. Sci. Nat. Zool.*, XVII, 1894, p. 353.

Extremely common on stones.

HYDROIDES NORVEGICA, Zunn. *De St. Joseph*, *Ann. Sci. Nat. Zool.*, V, 1898, p. 440.

On a stone at Petit Tor beach; numerous on buoys in Torquay Harbour.

SPIRORBIS BOREALIS, Daudin. *Caullery et Mesnil*, *Bull. Scien. de la France et de la Belgique*, XXX, 1897, p. 211.

Very common on Fucus.

SPIRORBIS SPIRILLUM, Lin. = *lucidus*, Mont. *Caullery et Mesnil*, *Bull. Scien. de la France et de la Belgique*, XXX, 1897, p. 198.

On *Sertularia abietina* thrown up on the shore.

Hermellidæ.

SABELLARIA ALVEOLATA, Linn. *Cambridge Nat. Hist.*, Vol. II, Figs. 131 and 135.

Very common all along the Torquay coast.

KEY TO THE GENERA OF THE EUNICIDÆ FOUND ON THE FRENCH AND ENGLISH COASTS OF THE CHANNEL.

Five prostomial tentacles.	Two frontal palps simulating stunted tentacles arising from the anterior border of the prostomium.	Two tentacular cirri on the second segment	Onuphis, Aud. and Edw.
		No tentacular cirri on the second segment	Hyalinœcia, Mgr.
	No frontal palps as above.	Two tentacular cirri on the second segment	Eunice, Cuv.
		No tentacular cirri on the second segment	Marphysa, Qfg.
Four tentacles.	Two dorsal and two ventral tentacles		Ophryotrocha, Clpd.
Three tentacles.	Branchiæ present, consisting of one filament		Amphiro, Kbg.
	No branchiæ		Lysidice, Sav.
Two tentacles.	Palps long. Denticles of upper jaw numerous, more than thirty. Feet with two branches		Staurocephalus, Gr.
One tentacle.	No branchiæ		Nematonereis, Schmarda.
No tentacles.	Compound bristles with toothed terminal pieces or simple hooked crotchets or both in some at least of the feet, in addition to simple winged capillary bristles		Lumbriconereis, Blv.
	Simple winged capillary bristles only.	Minute form parasitic in Syllids	Labrorostratus, de St. Joseph.
		Mandibles small or absent, the three anterior pairs of denticles consisting of simple hooks	Drilonereis, Clpd.
		Mandibles massive, the three anterior pairs of denticles consisting of toothed plates, or of one pair of hooks and two pairs of toothed plates	Arabella, Gr.

KEY TO THE SPECIES OF EUNICIDÆ FOUND ON THE FRENCH AND ENGLISH COASTS OF THE CHANNEL.

Genus Onuphis.

Tentacular cirri arise from the anterior border of the second segment. Tube flattened, made of small stones and shells	*O. conchylega*, M. Sars.

Genus Hyalinœciæ.

Branchiæ commence 23–26th foot. Tube translucent, quill-like. L., 100 mm.	*H. tubicola*, O. F. Müller.
Branchiæ commence on 4th segment. Brown bands on dorsum permanent in spirit. Tube of small shells and stones. L., 60 mm.	*H. Grubii*, Marenz.

Genus Eunice.

Body with numerous olive brown bands and spots, speckled with white. Maximum number of filaments of branchiæ, sixteen. L., 120 mm.	*E. fasciata*, Risso = *Harassi*, Aud. and Edw.
Three reddish bands on the back of each segment. Maximum number of filaments of branchiæ, five, on the 30th foot. L., 60 mm.	*E. vittata*, Delle Chiaje = *limosa*, Ehlers.

Genus Marphysa.

Branchiæ commence on 21st foot, filaments of branchiæ, arising from nearly the same spot, forming a tuft. Maximum number of filaments, eight. L., 400 to 600 mm.	*M. sanguinea*, Montagu.
Branchiæ commence on 14th foot, forming a comb. Maximum number of filaments, about twenty-five. L., 160 mm.	*M. Bellii*, Aud. and Edw.
Branchiæ consisting of a single filament. L., 15 mm.	*M.* fallax*, Mar. and Bohr.

Genus Ophryotrocha.

Small form. Segments with a girdle of cilia. L., 4 mm.	*O. puerilis*, Clpd. and Meczn.

Genus Amphiro.

Four eyes. Branchiæ commence on 16th segment. L., 9 mm.	*A.* Johnstoni*, Lang.

Genus Lysidice.

Head broad, flattened, with a median notch; tentacles short. Red spotted with white, the 4th segment entirely white. L., 100 mm.	*L. ninetta*, Aud. and Edw.

KEY TO SPECIES OF EUNICIDÆ—*continued.*

Genus Staurocephalus.

Palps earlike, not jointed. Back with brilliant red bands. L, 20 mm.	*S. rubrovittatus*, Gr.
Palps and tentacles jointed. Body colourless, covered with small glands, 4 eyes. L., 18 mm.	*S. ciliatus*, Kef.
Palps and tentacles jointed. Body colourless, no small glands, 2 eyes. L., 15 mm.	*S. pallidus*, Lang.

Genus Nematonereis.

Body greyish, very narrow, 1 mm. 2 eyes with short subulate tentacle arising between them. L., 200 mm.	*N. unicornis*, Gr.

Genus Lumbriconereis.

No jointed bristles in any of the feet.	Large forms.	Simple winged capillary bristles only in the anterior segments. Spines black. L., 120 mm.	*L. fragilis*, O. F. Müller.
		Simple winged capillary bristles accompanied by winged hooked crotchets in the anterior segments. Spines yellow. L., 500 mm.	*L. impatiens*, Clpd.
	Small forms.	Three winged hooked crotchets, no capillary bristles in the posterior segments. Front edge of mandibles furnished with very small double teeth. L., 21 mm.	*L.* labrofimbriata*, de St. Joseph.
		One winged hooked crotchet and one capillary bristle in the posterior segments. Supports of the maxillæ very long and narrow. L., 14 mm.	*L.* paradoxa*, de St. Joseph.
Jointed bristles present in some of the feet.	The jointed bristles in the anterior segments with very long terminal pieces. Head conical		*L. Latreilli*, Aud. and Edw. = *Nardonis*, Gr. = *Edwardsi*, Clpd. = *tingens*, Kef.
	The jointed bristles in the anterior segments with short terminal pieces. Head conical		*L. gracilis*, Ehlers.
	Head globular. Stalk of jointed bristles short and massive.		*L.* coccinea*, Ren.

Genus Drilonereis.

Upper dental apparatus with five pairs of jaws. Left maxilla with several small teeth at the base. L., 20 mm.	*D.* macrocephala*, de St. Joseph.
Upper dental apparatus with four pairs of jaws. Left maxilla not toothed at the base. L., 90 mm.	*D.* filum*, Clpd.

Genus Arabella.

Upper dental apparatus with five pairs of jaws. Lower part of the maxillæ with numerous small teeth. L., 250 to 450 mm.	*A. iricolor*, Montagu = *Maclovia gigantea*, Gr.

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* Not yet recorded from the British area.

KEY TO THE GENERA OF SPIONIDÆ FOUND ON THE FRENCH AND ENGLISH COASTS OF THE CHANNEL.

A. Fifth segment not enlarged, without special strong bristles.

Head without lateral horn-like projections.	Branchiæ on all the bristle-bearing segments, including the first			*Spio*, Fabr.
	Branchiæ on the second and a number of succeeding segments.	No dorsal winged hooks.	Anal cirri present. Dorsal lamella free from branchia	*Microspio*, Mesnil.
			Anus funnel-shaped. Dorsal lamella attached to branchia	*Nerenides*, Mesnil.
		Dorsal-winged hooks in some of the segments.	Anal cirri present. Dorsal lamina free from branchia	*Aonides*, Clpd. (*sensu* Mesnil).
			Anus funnel-shaped. Dorsal lamina more or less attached to branchia	*Nerine*, Johnston.
	Branchiæ present or absent from second segment. Absent from several of the following segments. Present on the twelfth to thirteenth segment and following segments			*Pygospio*, Clpd.
Head with lateral horn-like projections.	No branchiæ. Two of the ventral bristles of the first foot much thicker than the others			*Spiophanes*, Grube.
	Branchiæ on all the bristle-bearing segments			*Scolelepis*, Blv. (*sensu* Malmgren).

B. Fifth segment enlarged, furnished with special strong bristles.

Branchiæ commence on the second segment	*Boccardia*, Carrazzi.
No branchiæ before the sixth segment	*Polydora*, Bosc.

KEY TO THE SPECIES OF SPIONIDÆ FOUND ON THE FRENCH AND ENGLISH COASTS OF THE CHANNEL.

Genus Spio.

Prostomium rounded in front, usually four eyes, winged crotchets with two points commence at thirteenth to fifteenth segment. Anal cirri, four. L., 30 mm.	*S. martinensis*, Mesnil. =*filicornis*, Fabr. (?).

Genus Microspio.

Prostomium terminated by two rounded bosses, eyes four, anal cirri four. Winged crotchets commence ventrally on eighth foot. L., 10 mm.	*M. atlantica*, Langh. (?).

Genus Nerenides.

Prostomium very pointed, four eyes, lamella as long as and joined to branchia. Winged crotchets with two points. L., 70 to 100 mm.	**N. longirostris*, de St. Joseph.

Genus Aonides.

Prostomium pointed, four eyes in a line. About twenty pairs of branchiæ. Eight anal cirri. Winged crotchets with two points. L., 80 mm.	*A. oxycephala*, Sars.

Genus Nerine.

Winged crotchets with one point.	Dorsal lamella longer than and completely attached to the branchia in the first fifty segments ending in an obtuse point. L., 160 mm.	*N. foliosa*, Sars.
	Dorsal lamella attached for about three-quarters of the length of the branchia, then diverging and ending in a sharp point. L., 60 mm.	**N. Bonnieri*, Mesnil.
Winged crotchets with two points.	Head terminating in a sharp point; colour green. L. 70 mm.	*N. cirratulus*, Delle Chiaje.

Genus Pygospio.

Branchiæ on second bristled segment present. Stalks of winged crotchets without a distinct swelling. L., 10 mm.	*P. seticornis* (Œrsted *nec* Fabr.).
No branchiæ on second segment. Stalks with a distinct swelling. L., 10 mm.	*P. elegans*, Clpd., Mesnil.

Genus Scolelepis.

Winged crotchets with three points. L., 180 mm.	*S. vulgaris*, Johnston, McIntosh.
Winged crotchets with two points. Head and back marked with black pigment. L., 75 mm.	*S. fuliginosa*, Clpd.

* Not yet recorded from the British area.

KEY TO THE SPECIES OF THE SPIONIDÆ—*continued.*

Genus Spiophanes, Gr.

Tube dweller. Number of winged crotchets, eleven to fourteen. Anal cirri, two. L., 50 mm. . . *S. bombyx*, Clpd.

Genus Polydora.

Abnormal bristles of fifth segment with a comb-like fibrous crest. Dorsal bristles present on first segment. Branchiæ commence on seventh bristle-bearing segment. L., 8 mm.			**P. Caulleryi*, Mesnil.
Abnormal bristles ending in a single hook without lateral teeth or spines. Branchiæ commence on the eighth bristle-bearing segment. Number of winged crotchets usually three or four		Posterior segments with two or three needle-like spines. L., 20 mm.	*P. cœca*, Œrsted.
		Posterior segments without needle-like spines but with bundles of very fine bristles tapered at each end. L., 20 to 50 mm.	*P. flava*, Clpd. = *pusilla*, de St. Joseph.
Abnormal bristles with lateral teeth or projections in addition to main hook.	Stem of winged crotchets with a bulge. Branchiæ commence on seventh segment. Number of winged crotchets usually eight	Posterior segments with large dorsal bristles terminating in a strong hook. L., 50 mm.	*P. hoplura*, Clpd.
		Posterior segments without strong hooks. Extremities with more or less black pigment. L., 20 mm.	*P. ciliata*, Johnst.
	Stem of winged crotchets without a bulge. Number of crotchets from three to five	Branchiæ commence on the eighth bristle-bearing segment. Abnormal bristles ending in a truncated tip with nearly equal teeth, sometimes with a brush of fibres. L., 10 to 25 mm.	*P. quadrilobata*, Jac.
		Branchiæ commence on tenth segment. Abnormal bristles with a small tooth on concave side. L., 8 mm.	**P. Giardi*, Mesnil.
		Branchiæ commence on seventh segment. Abnormal bristles with a kind of hood on convex side, wings of hood forming two unequal points on the concave side. L., 5 mm.	*P. armata*, Lang.

Genus Boccardia.

Fifth segment with two different kinds of large bristles. L., 15 mm. . . . **B. polybranchia*, Hasw.

* Not yet recorded from the British area.

KEY TO THE GENERA AND SPECIES OF THE CIRRATULIDÆ FOUND ON THE FRENCH AND ENGLISH COASTS OF THE CHANNEL.

A transverse row of tentacular filaments (not distinctly thicker than the gill filaments) across one of the anterior segments.	Tentacular filaments appear on the same segment as the first lateral gills		No eyes. All the bristles capillary. L., 26 to 40 mm.	**Cirratulus filiformis*, Kef.
			Eyes present. Two kinds of bristles, capillary and crotchets. L., 125 mm.	*Cirratulus cirratus*, Müller.
	Lateral gills appear on one or more of the segments in front of the segment which carries the tentacular filaments		No eyes. L., 200 mm.	*Audouinia tentaculata*, Aud.
A pair of tentacular filaments (distinctly thicker than the gill filaments) present.	Gill filaments (few, four to eight pairs). Tentacular filaments inserted below gill filaments. L., 25 mm.			*Dodecaceria concharum*, Œrsted.
	More than eight pairs of gill filaments. Tentacular filaments inserted above gill filaments.	Crotchets and eyes present.	Crotchets truncate at apex. Capillary bristles present in all the neuropods. L., 16 mm.	*Heterocirrus caput esocis*, de St. Joseph.
			Crotchets bifid. No capillary bristles in neuropods after the third segment	*Heterocirrus viridis*, Lang = *flavoviridis*, de St. Joseph.
		Crotchets and eyes absent. Bristles all capillary		**Tharynx* (*Heterocirrus*) *Marioni*, de St. Joseph.

* Not yet recorded from the British area.

KEY TO THE GENERA AND SPECIES OF THE MALDANIDÆ ON THE FRENCH AND ENGLISH COASTS OF THE CHANNEL.

Funnel of anal segment with numerous teeth or cirri.	No small papillæ on posterior segments . .	Back of head with several indentations. Teeth of anal funnel equal or unequal. The three segments preceding the anal segment without bristles. Breadth, 8 mm. L., 150 mm.	*Clymene* (*Euclymene*) *lumbricoides*, Qfg.
		Back of head not indented. Teeth of anal funnel very unequal, sometimes with one long ventral cirrus. The two segments preceding the anal segment without bristles. Breadth, 1 mm. L., 80 mm.	*Clymene* (*Euclymene*) *Œrstedi*, Clpd.
	Papillæ arranged in two longitudinal rows in posterior segments . .	Anal funnel with teeth of equal length. Crotchets of first three bristle-bearing segments ending with three little teeth and one large tooth directed upwards	**Johnstonia clymenoides*, Qfg.
Anal segment without teeth or cirri.	Anal segment cup-shaped, with a central conical anus. Twenty-five to twenty-nine bristle-bearing segments. Breadth, 3 mm. L., 200 mm.		*Leiochone clypeata*, de St. Joseph.
	Anal segment with a concave leaf-like appendage, on the surface of which the anus opens. Twenty-two bristle-bearing segments. Breadth, 3 mm. L., 130 mm.		**Petaloproctus terricola*, Qfg.

* Not yet recorded from the British area.

KEY TO THE SPECIES OF TEREBELLIDÆ FOUND ON THE FRENCH AND ENGLISH COASTS OF THE CHANNEL.

Capillary bristles with very fine saw-like teeth near the end. Three or two pairs of gills.	Capillary bristles in the thoracic region only. Uncini with six rows of transverse teeth which are numerous in the upper rows.	Each gill consists of a tuft of unbranched filaments. Three pairs of gills. Capillary bristles in seventeen segments. Tentacles with brown marks. L., 80 mm.		*Amphitrite cirrata*, O. F. Müller.
		Each gill consists of a main stem with numerous branches.	Capillary bristles in twenty-four segments. Three pairs of gills. Tentacles white. L., 200 mm.	*Amphitrite Johnstoni*, Mgr.
			Capillary bristles in seventeen segments. Three pairs of gills. Tentacles orange. L., 230 mm.	*Amphitrite Edwardsi*, Qfg.
			Capillary bristles in seventeen to twenty segments. Two pairs of gills. Tentacles white, body very red in front. Uncini in front part of abdomen in double rows. Eyes present. L., 100 mm. . . .	*Amphitrite gracilis*, Grube.
	Capillary bristles throughout the body. Uncini with three or four rows of three to six teeth. Tentacles red. Eyes present. L., 55 mm.			*Terebella (Lepræa) lapidaria*, L.
Capillary bristles with smooth tips in seventeen segments. Three pairs of branched gills.	Uncini with two transverse rows of one, two, or three teeth.	The eighth to seventeenth bristle-bearing segments with a double row of uncini interlocking half-way. Body red or brown, spotted with white. Tentacles white or reddish. Eyes present. L., 200 mm.		*Polymnia nebulosa*, Mont.
		The eighth to seventeenth bristle-bearing segments with a single row of uncini. Body red or brown. Tentacles bright orange. Eyes present. L., 50 mm.		*Polymnia nesidensis*, Delle Chiaje.
		The eighth to seventeenth segments with a double row of uncini placed back to back. Lower thoracic shields intensely red. Tube fringed at the ends with strings of sand. L., 100 to 270 mm.		*Lanice conchilega*, Pallas.
	Uncini without transverse rows of teeth, comb-like, with four to six teeth; the terminal divisions of the gills very fine and numerous			*Loimia medusa*, Sav.

KEY TO THE SPECIES OF TEREBELLIDÆ—*continued.*

Capillary bristles with smooth tips in fifteen to seventeen segments; two (rarely three) pairs of branched gills.	Uncini with two transverse rows, with three to five teeth. The eighth to seventeenth segment with a single row of uncini. Body red, spotted with white. Tentacles dark red, short. Eyes present. L., 50 mm.	*Nicolea venustula*, Mont. =*zostericola*, Oerst. (?).
	Uncini with three to five transverse rows of three to twelve teeth, and a very long projection at the posterior angle of the base. Gills brush-like, with spirally arranged branches. Body and tentacles reddish. L., 75 mm.	*Pista cristata*, Müller.
Capillary bristles with smooth tips in sixteen segments; one pair of branched gills.	Uncini with three transverse rows of three to six teeth. Body red, spotted with brown. Tentacles red, sometimes spotted with brown. L., 60 mm.	*Scione maculata*, Dalzell.
Capillary bristles with smooth tips in numerous (over thirty) segments. Uncini with two transverse rows of two to three teeth. Gills, consisting of simple filaments, arranged in rows.	Body orange, without any pattern on the skin. Tentacles spotted with red. Gills on two segments. L., 120 mm.	*Thelepus cincinnatus*, Fabr.
	Body marked in a pattern with white lines. Gills on three segments. L., 160	*Thelepus setosus*, Qfg.
Capillary bristles with smooth tips in eighteen segments. One gill, consisting of four comb-like plates arising from a single peduncle.	Crotchets with a long stalk in front part of body. Uncini, in posterior part, comb-like. L., 60 mm.	*Terebellides Stroemi*, Sars.

KEY TO THE SPECIES OF TEREBELLIDÆ—*continued.*

Capillary bristles with smooth tips in fifteen segments. Gills, three pairs, each gill consisting of a single filament.		Crotchets with a long stalk in front part of body. Uncini in posterior part. Body orange. Tentacles violet. L., 30 mm.	*Trichobranchus glacialis*, Mgr.
No gills and no blood-vessels.	Capillary bristles smooth. None of them winged. Body and tentacles orange.	Number of segments with capillary bristles about twenty-eight to sixty. Uncini appear at ninth bristle-bearing segment. Six pairs of nephridia. L., 30 to 100 mm.	*Polycirrus caliendrum*, Clpd.
		Number of segments with capillary bristles about twenty-eight to forty. Uncini appear at seventh to ninth bristle-bearing segment. Three pairs of nephridia. L., 80 to 100 mm.	*Polycirrus aurantiacus*, Grube.
	Capillary bristles smooth. Some of them slightly winged.	Conspicuous red blood. No uncini in the first twelve bristle-bearing segments. Six pairs of nephridia. L., 16 mm.	**Polycirrus hæmatodes*, *Clpd.*
		Entirely colourless. Uncini appear at the seventh to tenth bristle-bearing segment. Three pairs of nephridia. L., 16 mm. . . .	**Polycirrus tenuisetis*, Langhs.
	Capillary bristles denticulated.	Colourless, or very slightly tinged with yellow. Number of segments, with capillary bristles, about fifteen	**Polycirrus denticulatus*, de St. Joseph.

* Not yet recorded from the British area.

KEY TO THE GENERA AND SPECIES OF THE SABELLIDÆ FOUND ON THE FRENCH AND ENGLISH COASTS OF THE CHANNEL.

A. Ventral bristles of the thorax of two different kinds, namely simple winged capillary bristles and uncini.

Peristomium produced to form a collar.	Gill filaments arising from a spiral base.	The two parts of the branchial crown unequal. Dorsal bristles of the thorax of one kind. L., 260 mm.				*Spirographis Spallanzii*, Viv.
		The two parts of the branchial crown equal. Dorsal bristles of the thorax of two kinds. L., 130 mm.				*Bispira voluticornis*, Mont.
	Gill filaments not forming a spiral.	No eyes near the end of the gill filaments.	Dorsal bristles of the thorax of one kind. No eyes.	Tube of mud. Gill filaments long, 40 mm. L., 200 mm. . . .		*Sabella pavonina*, Sav.
			Dorsal bristles of the thorax of two kinds, namely narrow winged bristles and shorter spathulate bristles.	Eyes on the lower part of some of the gill filaments. L., 75 mm. .		*Potamella reniformis*, Müller.
				No eyes on gill filaments. Two eyes on peristomium, and six or eight on anal segment .	No otocysts. L., 20 mm.	*Potamilla Torelli*, Mgr.
					Two otocysts. L., 20 mm.	*Potamilla incerta*, Lang.
		Eyes near the end of gill filaments. Tube of sand, small stones, and fragments of shells. L., 100 mm.				*Branchiomma vesiculosum*, Mont.
Peristomium without a collar.	Eyes in peristomium and anal segment. Two otocysts in first bristled segment. Gill filaments five on each side. Number of segments about forty. L., 8 mm. . .					*Amphiglena mediterranea*, Clpd.

KEY TO THE GENERA AND SPECIES OF THE SABELLIDÆ—*continued.*

B. Ventral bristles of the thorax of one kind, namely, either uncini or crotchets with a long stalk.

- Ventral bristles of thorax uncini . Each gill filament carries a number of eyes. Two clublike dorsal appendages arise from near each pair of eyes. L., 30 mm. . . . . — *Dasychone bombyx*, Dalyell.
- Ventral bristles of thorax crotchets with a long stalk.
  - Gill filaments not connected by a fine membrane.
    - Dorsal bristles of thorax of one kind, namely, capillary bristles with long tapering ends .
      - Crotchets in abdomen with a long stalk. Gill filaments five on each side. No long secondary branches to the filaments. L., 6 mm. — *Haplobranchus æstuarinus*, Bourne.
      - Uncini in abdomen. Secondary branches of gills of unequal length reaching the same level.
        - Gill filaments three or four on each side. Peristomial collar present. Eyes in anterior and anal segments. Bristle-bearing segments in abdomen, six to seven. L., 6 mm. — *Oria Armandi*, Clpd.
        - Gill filaments three on each side. No peristomial collar. Eyes in anterior and anal segments. Bristle-bearing segments in abdomen, three. L., 3 mm. . . . . — *Fabricia sabella*, Ehr.
    - Dorsal bristles of thorax of two kinds, namely, bristles with long tapering ends, and others with short spathulate ends . . Gill filaments eight to twelve on each side. Secondary branches short, of equal length. Two eyes in anterior segments. Number of segments, thirty-five to forty. L., 15 mm. — *Jasmaneira elegans*, de St. Joseph.
  - Gill filaments connected by a fine membrane reaching nearly to their tips.
    - No eyes on peristomium. Gill filaments not enlarged near the ends, mud-dweller, tube gelatinous. Large worm. L., 220 mm. . . — *Myxicola infundibulum*, Renier.
    - Eyes present on peristomium. Gill filaments enlarged near their tips; inhabits oyster shells . . . . — *Myxicola Dinardensis*, de St. Joseph.

KEY TO THE GENERA AND SPECIES OF THE SERPULIDÆ OF THE FRENCH AND ENGLISH COASTS OF THE CHANNEL.

Uncini with many teeth, the last tooth longer, broader, and blunter than the others. Tube spiral.

Operculum on the right of the median dorsal line.	No brood pouch in operculum.	Tube semi-transparent. Common on *Sertularia abietina*. Ten to sixteen bristle-bearing segments in the abdomen		*Spirorbis spirillum*, L. = *lucidus*, Mont.
		Tube opaque on lobsters and crabs. Sixteen to twenty bristle-bearing segments in the abdomen		*Spirorbis sinistrorsus*, Mont. = *armoricanus*, de St. Joseph.
	Brood pouch in operculum.	Operculum resembling a barrel. No sickle-shaped bristles in the third bristle-bearing segment		*Spirorbis corrugatus*, Mont.
		Operculum smooth. Sickle-shaped bristles in the third bristle-bearing segment	Hepatic pigment violet	**Spirorbis Pagenstecheri*, Qfg.
			Hepatic pigment red	**Spirorbis pusillus*, de St. Joseph.
Operculum on the left of the median dorsal line.	No brood pouch in operculum. Operculum not strongly convex at end.	Four bristle-bearing segments in the thorax		**Spirorbis Malardi*, Caullery and Mesnil.
		Three bristle-bearing segments in the thorax.	No teeth or excrescence on operculum	*Spirorbis borealis*, Daudin.
			Teeth or excrescences present on operculum	*Spirorbis cornu arietis*, Phil.
	Brood pouch in operculum. Operculum strongly convex at end.	Top of operculum with serrated edges		**Spirorbis militaris*, Clpd.
		No serrated ridges, a smooth rim round the operculum		*Spirorbis granulatus*, L. *nec* Lang.

* Not yet recorded from the British area.

KEY TO THE GENERA AND SPECIES OF THE SERPULIDÆ—*continued.*

Uncini deeply hollowed out at back with very numerous and very small teeth, terminated by a stout spine. Tube not spiral	No operculum. No sickle-shaped bristles present in the thorax. L., without gills, 20 to 45 mm.	*Protula tubularia*, Mont.
	Operculum globular, transparent. Some sickle-shaped bristles with winged stalks present in thorax. L., 8 to 15 mm.	*Apomatus similis*, Mar. and Bohr.
Uncini with about fourteen teeth, last tooth broader, blunter, and larger than the others. Tubes very slender, intertwining	Two opercula at the end of stems with secondary branches. Ends of gills not enlarged. L., 5 mm.	*Filograna implexa*, Oken.
	No operculum. Ends of gills club-shaped and hollowed out. L., 6 mm.	*Salmacina Dysteri*, Huxley.
Uncini with eight or nine teeth, the last tooth hollowed out underneath like a gouge .	Tube adherent usually with three ridges, the centre ridge projecting in a sharp tooth over the orifice. Operculum with two projections on the stem, flat at the top or conical, with or without one to three spines .	*Pomatoceros triqueter*, L.
Uncini with five to seven teeth, the last tooth stronger than the others, but pointed like them	Operculum funnel-shaped, margin crenate. Gills about thirty on each side. Number of teeth in uncini of thorax five. L., 20 to 50 mm. .	*Serpula vermicularis*, L.
	Operculum funnel-shaped with a circle of spines, with thorns on their spines arising from the centre. Number of teeth in uncini of thorax seven. Gills about fifteen to seventeen on each side. L., 20 mm. .	*Hydroides norwegica*, Gunn.

Some Notes on the Genus Cumanotus.

By

Nils Odhner.
Fil. Lic., Stockholm.

In 1908 Sir Charles Eliot published in the *Journ. Mar. Biol. Assoc.*, Vol. VIII, No. 3, a paper "On the Genus Cumanotus"; in that paper he showed that *Coryphella beaumonti*, discovered and named by him in 1906,* was to be referred to the above genus, which had been first established by myself in 1907 from a study of the Norwegian *C. laticeps*, described at the same time as a new species.†

Sir Charles Eliot also called attention to the striking resemblance of the two forms, and remarked that their identity was not improbable, though he assumed that there might be some differences in the denticulation of the jaws and the lateral teeth of the radula.

Through the kindness of Sir Charles Eliot and of Mr. De Morgan, Acting-Director of the Plymouth Laboratory, I have procured two specimens of *C. beaumonti* for comparison with the Norwegian *C. laticeps*, with a view to determine the distinguishing characters of the two forms.

In exterior appearance they are quite alike, and I have found no difference of a specific value in their habitus. The proportions of the body are nearly the same, as is evident from the following measurements (in *mm.*):—

	C. beaumonti.	*C. laticeps.*
Length of body	14	13
Breadth ,, ,, ...	5·5	5·3
,, ,, head	4·2	4
Length ,, rhinophores	4·3	4·3
,, ,, a few papillae in the 5th row	3·7	4

The height of the body was somewhat greater in *C. beaumonti* than in *C. laticeps*, which probably depends on their varying states of preservation.

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* "Notes on Some British Nudibranchs," l.c., Vol. VII, No. 3, 1906.

† "Northern and Arctic Invertebrates, III, Opisthobranchia," *K. Sv. Vet.-Akad. Handl.*, Bd. 41, No. 4, 1907.

In both forms the soft parts fully agree in shape. On the head there are situated two small conical tentacles of the same size and position in both, connected by a low cutaneous fold. The rhinophores are close to each other, and are united at the base. The foot is extended, forming two pointed angles at the frontal sides, and is expanded laterally and posteriorly to a cutaneous border.

The arrangement of the dorsal papillae is also of the same character in both. They are set in about 12 transverse rows, the 3 foremost ones being placed in front of the rhinophores. The rows are in two groups, a pre-anal and a post-anal one, the first embracing 6 rows; the anus is situated dorso-laterally, immediately in front of the 7th row.

As to the number of papillae, this has been easy to determine in *C. beaumonti*, for all the papillae there were intact; in *C. laticeps*, on the other hand, they had fallen off to a great extent, and the statements here given are therefore deduced from the markings. One specimen of each form was examined.

The number of papillae was as follows:—

	C. beaumonti.	*C. laticeps.*
In the 1st row	2	3
,, 2nd ,, ...	4	6
,, 3rd ,, ...	7	8
,, 6th ,, ...	9	9
,, 7th ,, ...	8	6
,, 8th ,, ...	6	6
,, 9th ,, ...	4	4
,, 10th ,, ...	4	4

The unimportant difference which was present in the two specimens examined may be quite individual, and any attempt at deducing specific characters is therefore excluded.

Anatomically the papillae are of the same structure, for in both forms they are furnished, at the tips, with a saccus cnidophorus, which is connected with the liver process by means of a narrow, winding canal.

Of all the characters distinctive of the genus Cumanotus, the shape of the female copulatory organ is the most peculiar. To the sides of the bursa copulatrix there are attached two circular pads with a papillated margin, and these papillae are of the same number, 12, in both forms. Such difference in dimensions as was observable in homologous parts is to be explained by their different stages of maturity.

Thus exteriorly the soft parts show an entire conformity, and from them consequently no specific characters are obtainable. There only remains the inner anatomy to be dealt with; but here I considered it unnecessary to compare the whole organization of the two forms in detail, and I have accordingly only examined the organs that are primarily of specific value, viz. the radula and the mandibulae.

The rows of the radula in *C. beaumonti* vary in number from 16 to 24, according to Eliot; in *C. laticeps* I have found about 17. The teeth are furnished in both forms with long, slightly curved cusps. The form and the denticulation of the median tooth do not present any differences. The lateral teeth are denticulated only on the inner sides. In the latest formed part of the radula, I have found the number of denticles of the laterals circa 25 in *C. beaumonti* and 18 in *C. laticeps;* in the older part above 25 and about 22 respectively. This slight difference is of no consequence, especially as the form and curvation of the lateral teeth are the same in the two specimens examined.

There remains only one more character to consider, the structure of the mandibulae, but here too I have found entire agreement. Their form and colour correspond, as do those of the whole bulbus pharyngeus too. The mandibulae are lengthened, roundly quadrangular, and denticulated in the anterior margins. In the denticulation there exists but a slight difference, the denticles seeming to be placed at somewhat greater intervals in *C. laticeps* than in the other. As to the shape of the denticles, I have found them in both forms to be somewhat irregular, uni-, bi- or tricuspidate, the more complicated ones being situated in the upper or anterior part of the jaw margin, a part which is most worn. The denticles are arranged in one row only at the margins. Two specimens of each were examined. In these mandibular characters also the forms agree wholly with one another.

It has consequently not been possible to find out any specific distinguishing points between the two forms; in all the characters they are alike. I therefore consider their identity to be proved. Nor are there any good reasons for their severance as varieties; it is hardly probable either that any would be obtainable from the characters of the living animal, though the colouring might doubtless be subject to some variation, as is usual with the Nudibranchs.

As a result of the above comparison, I consider the genus Cumanotus to consist of one species only, viz. *C. beaumonti* (Eliot, 1906), and regard my own species, *C. laticeps*, Odhner, 1907, as a synonym. *C. beaumonti* consequently has a wide distribution, being obtained in England as well as in Northern Norway. Further investigations will certainly show its occurrence also in the intermediate districts.

Kodioides borleyi, n.sp.

By

Chas. L. Walton.

In his Report on the Actiniaria of the Norwegian North-Atlantic Expedition, D. C. Danielssen erected the genus *Kodioides* to receive the remarkable form which he named *K. pedunculata*, a single specimen of which was dredged at Station 35, July 5th, 1876, in 1050 fathoms, Lat. 63° 17′ N., Long. 1° 27′ W., the bottom being Biloculina Clay. The detailed description will be found in the section "Actinida," Vol. V, pp. 77–82, Pl. VI, Figs. 3–4; XXII, 8–11; and XXIII, 1–4. The genus is there characterized as follows: "The body encrusted, piriform, with a long bare stem terminating in a pedal disc. Two series, containing a few retractile tentacles. 12 pairs of septa, of which 6 pairs perfect. Suckers on the encrusted portion of the body. No gullet-groove. Mesodermal, annular muscles. Acontia."

During a visit to Lowestoft last summer, Mr. J. O. Borley handed to me for examination 2 specimens of an Actinian obtained some time previously by the s.s. *Huxley*, Voyage XXX, Station 23, Lat. 53° 46′ N., Long. 4° 52′ E., N.N.W. of Terskelling. Depth, 20 fathoms. Bottom, mud. Conical dredge. Two specimens. A very short examination convinced me that I had before me specimens referable to the genus *Kodioides*. The species, however, is evidently distinct, as might be expected, *K. pedunculata* being obtained in the cold area, from 1050 fathoms, between the Faroë Islands and Norway; and these from 20 fathoms, and comparatively close to the Dutch coast.

It is unfortunate that no description was made while the animals were living, but Sea Anemones are difficult to deal with; indeed, it is frequently impossible to do so under bad-weather conditions and during the pressure of fishery work. Danielssen mentions the difficulties he experienced with *K. pedunculata*. Further, when I examined the specimens they were by no means in the best condition, being somewhat decayed.

Specimen (*a*).—Measurements, etc., were as follows: Animal strongly contracted:—

Total length, 48 mm. Length of body, 21 mm.; breadth, 16 mm.

Length of stalk, 25 mm.; breadth, just below body, 5 mm.; lower portion, 3 mm.

Pedal disc irregular in outline, breadth, 15 mm. (on the average); thickness, 3 mm. On the body were remains of a slight coating of mucus and sand grains, and a thick coating of mud adhered to the pedal disc. The ectoderm was much decayed, but remains of what appear to have been suckers could be made out.

The body was considerably wrinkled. Stem bare and smooth. The upper surface of the pedal disc and base of stem showed numerous fine lines. There was a considerable tumid excrescence on the lower portion of the body, much decayed, and probably due to injury received in the dredge. Neither the oral disc nor tentacles were visible.

Specimen (*b*).—Total length, 32 mm. Body wrinkled and thickly coated with sand at the summit. Pedal disc irregular in outline, much smaller than in (*a*); under surface bare and much ridged and folded. This individual was only partially contracted, and showed the tentacles and portions of the oral disc. Oral disc strongly ridged, but owing to decay the number and details could not be made out; mouth also not visible for the same reason.

Tentacles (partially contracted) short, stout, and obtuse, in 3 or 4 series, about 90 in number; but they were difficult to enumerate, and in several places a number had been injured or destroyed.

Colours.—Mr. Borley informed me that when alive the body was yellowish white, longitudinally striped with dull red. Tentacles, dull red (?). Nothing remained when examined but a dull uniform pinkish shade. Horizontal and vertical section with a razor disclosed a state of decay, amidst which little could be recognized; I can only say that no siphonoglyph could be found in either (*a*) or (*b*), and that the mesenteries in (*a*) were about 24 pairs fully developed, and a similar number incomplete.

The general appearance of both specimens is very similar to Danielssen's figures and description of *K. pedunculata*, as also are the measurements; the features that cause me to consider these examples as a separate species being the marked difference in the number of mesenteries and tentacles. I here repeat the generic characteristics as given by Danielssen, so altered as to include the present species:—

The body encrusted, piriform, with a long bare stem, terminating in a pedal disc. Tentacles few or many, in two or more series, retractile. 12 or more pairs of mesenteries, half of their number perfect.

Suckers on the encrusted portion of the body. No siphonoglyph.

Mesodermal, annular muscles. Acontia.

Specific characters.—*K. pedunculata:* mesenteries, 12 pairs, tentacles 24.
K. borleyi: mesenteries and tentacles numerous.

It is to be hoped that further specimens may be obtained before long, which would enable a thorough anatomical examination to be made and the true affinities of this remarkable genus determined, as the condition of the specimens here described was not sufficiently good to permit of any observations as to acontia and many other points of interest.

In view of the peculiar form of these anemones, it may be of interest to quote Danielssen's remarks concerning *K. pedunculata:* "The weather was very stormy at the time, and the vessel had a constant heaving and rolling movement, which in a great degree obstructed the investigations. I was, however, fortunate enough to obtain the animal drawn in the live state, and to jot down some observations in regard to its exterior; but as it constantly kept itself pretty much shrunk together, although I had had it for several days in the glass vessel for observation, I could determine nothing in respect of the tentacles, only so much did I observe, viz. that the stem sometimes kept itself quite erect and at other times became bent, whilst the body expanded and contracted—movements which were participated in by the stem in such manner that when the body contracted the stem became attenuated, and when the body expanded the stem became tumified."

Marine Biological Association of the United Kingdom.

Report of the Council, 1909-10.

The Council and Officers.

Four ordinary meetings and one special meeting of the Council have been held during the year at which the average attendance has been thirteen. A Committee of the Council visited and inspected the Plymouth Laboratory.

The Council desire to express their thanks to the Councils of the Royal Society and of the Linnean Society, in whose rooms their meetings have been held.

The work in connection with the International Fishery Investigations, which the Council has been carrying out during the last seven years for His Majesty's Government, has now been taken over by the Board of Agriculture and Fisheries.

The Plymouth Laboratory.

The Laboratory, including the pumps and engines used for circulating sea-water through the tanks, has been maintained in an efficient state. An air-circulation from a pump worked by the gas engine has been rearranged in such a way that an abundant supply of pure air is now available for use in small aquaria and experimental tanks.

The Boats.

The steam trawler *Huxley*, which has been used for work in connection with the International Investigations, has been sold.

The *Oithona* was again fitted out for summer work at the Plymouth Laboratory, Captain J. Tucker, who has been in charge of the *Huxley*, being in command.

The winter collecting has been done as usual with the sailing boat *Anton Dohrn*.

The Staff.

Messrs. Borley, Todd, Wallace, Hefford, Atkinson, and Wollaston and Miss Lee have accepted service under the Board of Agriculture and Fisheries in connection with the International Investigations.

Mr. E. W. Nelson is accompanying Captain Scott to the Antarctic as biologist.

Mr. L. R. Crawshay has resigned the post of Assistant-Director owing to ill-health, and Mr. A. J. Mason-Jones has accepted an appointment as lecturer in biology at the Plymouth Technical Schools.

An arrangement has been made by which the services of Mr. D. J. Matthews will be partly retained by the Association. The Council are glad to say that Mr. Matthews, Mr. Crawshay, and Mr. Mason-Jones continue to work at the Laboratory.

The Director, Dr. E. J. Allen, has delivered a course of twenty-four lectures on Marine Biology and Fishery Investigations at the Imperial College of Science and Technology, South Kensington. During his absence Mr. W. De Morgan acted as Deputy-Director.

Occupation of Tables.

The following Naturalists have occupied tables at the Plymouth Laboratory during the year:—

Prof. SVANTE ARRHENNIUS, Stockholm (Experimental Embryology).
W. DE MORGAN, Plymouth (Hybridization of Echinus).
G. H. DREW, B.A., Plymouth (Experimental Pathology).
J. S. DUNKERLY, B.SC., London (Protozoa).
Prof. F. W. GAMBLE, F.R.S., Birmingham (Colour Physiology).
E. S. GOODRICH, F.R.S., Oxford (Fishes).
G. H. GROSVENOR, M.A., Oxford.
Miss HARRISON, Oxford (Experimental Embryology).
M. D. HILL, M.A., Eton (Alcyonium).
C. KILLIAN, Freiburg (Laminaria).
D. G. LILLIE, Antarctic Expedition.
Prof. JACQUES LOEB, California (Experimental Embryology).
W. NICOLL, M.D. (The Entozoa of Marine Fishes).
Miss POOLE, Oxford (Development of Tectibranchiata).
CARR SAUNDERS, M.A., Oxford (Development of Tectibranchiata).
C. SHEARER, M.A., Cambridge (Histriobdella and Dinophilus).
GEOFFREY SMITH, M.A., Oxford (Bacteriology of Crabs).
E. R. SPEYER, Oxford (General Zoology).
R. WHITEHOUSE, M.SC., Birmingham (Fishes).
Miss GERARDA WIJNHOFF, Utrecht (Nemertines).
W. WOODLAND, D.SC., London (Gobius).
Miss YONKER, Utrecht (General Zoology).

In addition to the above, nineteen students attended the Laboratory during the Easter vacation, when Mr. G. H. Grosvenor conducted the usual course of instruction in Marine Biology.

The Library.

The thanks of the Association are due for the following books and current numbers of periodicals presented to the Library during the past year:—

Académie Imp. des Sciences de St. Pétersbourg. Bulletin.
American Museum of Natural History. Bulletin.
—— Memoirs.
American Microscopical Society. Transactions.
American Philosophical Society. Proceedings.
Armstrong College. Calendar.
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—— Memoirs.
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—— Annual Report of Proceedings under Acts relating to Sea Fisheries.
—— Monthly Return of Sea Fisheries, England and Wales.
—— Report of Proceedings of Annual Meeting.
—— Report on the Research Work of the Board in relation to the Plaice Fisheries of the North Sea.
Boston Society of Natural History. Proceedings.
Bristol Naturalists Society. Proceedings.
British Museum. Catalogue of the Books, Manuscripts, Maps, and Drawings in the British Museum (Natural History).
—— Catalogue of the Fresh-water Fishes of Africa in the British Museum (Natural History).
Brown University. Contributions from the Biological Laboratory.
Brooklyn Institute of Arts and Sciences. Science Bulletin.
Bulletin Scientifique de la France et de la Belgique.
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California Academy of Sciences. Proceedings.
Cambridge Natural History. Crustacea and Arachnids.
Carnegie Institution of Washington : Scope and Organization.
—— Dept. of Marine Biology. Annual Report of the Director.
—— Inheritance in Canaries, by C. B. Davenport.
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Dept. of Marine and Fisheries, Canada. Annual Report.
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—— Description of a new Isopod of the Genus Jaeropsis from Patagonia. By H. Richardson.

—— Revision of the Crinoid Family Comasteridae, with Descriptions of new Genera and Species. By A. H. Clark.

—— On a Collection of Recent Crinoids from the Philippine Islands. By A. H. Clark.

—— Four New Species of the Crinoid Genus Rhizocrinus. By A. H. Clark.

—— Descriptions of Seventeen New Species of Recent Crinoids. By A. H. Clark.

—— Report on Barnacles of Peru, collected by Dr. R. E. Coker and others. By H. A. Pilsbry.

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—— Fresh-water Sponges collected in the Philippines by the *Albatross* expedition. By N. Annandale.

—— The Polychaetous Annelids dredged in 1908 by Mr. Owen Bryant off the coasts of Labrador, Newfoundland, and Nova Scotia. By J. P. Moore.

—— Fresh-water Sponges in the Collection of the U.S. National Museum. By N. Annandale.

—— Description of a New Terrestrial Isopod from Guatemala. By H. Richardson.

—— The Snapping Shrimps (Alpheidæ) of the Dry Tortugas, Florida. By H. Coutière.

—— Cœlenterates from Labrador and Newfoundland. Collected by Mr. Owen Bryant, from July to October, 1908. By H. B. Bigelow.

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—— Note on the Occurrence of *Hippolyte gracilis* (Heller) in the British Area.

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General Work at the Plymouth Laboratory.

A report by Dr. Allen and Mr. Nelson on the experiments which they have carried out at the Laboratory on the artificial culture of marine plankton organisms has been published in the Journal of the Association. In this paper it is shown that plankton diatoms can be grown, under laboratory conditions, in persistent cultures containing a single species, and that pelagic larvæ can often be reared through their metamorphosis by keeping them in sterile sea-water and feeding them on such diatom cultures.

Mr. G. H. Drew has been working at the Laboratory during the year on the diseases of fishes, and has also been studying the question of abnormal growths in other marine animals. Mr. Drew has recently been elected a Beit Memorial Fellow for medical research, and is thus able to devote his whole time to a continuation of these studies.

The work of collecting and identifying the larvæ and young stages of fishes has been continued by Mr. A. E. Hefford during the year, and the results now tabulated for publication include collections from 1906 to 1909. The study of embryonic and early larval stages has been made upon tow-netted pelagic eggs kept under observation in the Laboratory. The MS. and coloured drawings for a report on this part of the work for 1909 are ready for publication, to which is added an appendix describing the larval stages of *Solea lascaris*, completely observed for the first time this spring. Many larval and post-larval forms have been added to the Museum collection.

A short report on experiments upon the influence of low temperatures on the turbot has been sent to the New Zealand Government, who asked for the information with a view to acclimatizing the turbot in New Zealand.

Specimens of marine animals and plants have, as usual, been supplied to many museums and colleges in all parts of the world for teaching purposes, as well as to many individual workers for the purposes of research. Parties of boys and girls from a number of Plymouth schools have been admitted from time to time to the Aquarium free of charge.

The International Fishery Investigations.

The following is a summary of the work done, and of the conclusions arrived at by the scientific staff working under the direction of the Council.

SECTION I.—NORTH SEA WORK.

A. WORK AT SEA.

From June 1st, 1909, to the end of October, when she was finally laid up, the *Huxley* made four voyages, in the course of which 42 hauls of the commercial trawl were made, while smaller gear was used at 67 stations. The total number of voyages made by the *Huxley* during the participation of the Association in the International Investigations is

112; and her employment on North Sea fishery research having now terminated, the total number of hauls made from her decks in connection with this work in the North Sea may be stated. It is as follows:—

Commercial Gear: Otter trawl, 569; Beam trawl, 920. Total, 1489 hauls.

Small Gear: Shrimp trawl, 134; Agassiz trawl, 173; Todd's trawl, 47; Dredge, 177; Conical dredge, 599; D-net, 8; Oyster dredge, 3; Petersen's Young-fish trawl, 113.

Hensen net, 65; Brood nets, 40; Garstang net, 34; other tow-nets, 120. Total, 1513 hauls.

The total number of stations at which small gear has been used is 1337, but as on many occasions more than one net was used at a station, the number of hauls is higher, reaching, as shown above, 1513. In addition to the operations of the *Huxley* in the open sea, data have been collected from time to time, as has been stated in previous reports, concerning the shallower coastal waters. With the co-operation of the Eastern Sea Fisheries District Committee in the Wash, and by the employment of the Association's steamer *Oithona* in Bridlington Bay, in the Suffolk bays and estuaries, and in the Thames, it has been possible to collect valuable information concerning all of the more important English inshore areas, that concerning the Wash being the most extensive. Sixty-four hauls of the small Otter trawl were made from the *Oithona*, while the use of the Shrimp trawl, shore nets, Conical dredge, and other gear brings the total number of hauls from this vessel in the North Sea up to 102.

FISH MEASURED.—As in former years, the total catch of fish was again measured this year on nearly all occasions: owing to the devotion of a considerable time to the collection of fish eggs and larvæ, the number measured is, however, somewhat less than during 1908–9. The details as to the number of plaice, haddock, and other species dealt with are as follows:—

YEAR.		PLAICE.	HADDOCK.	OTHERS.		TOTALS.
1902–9	...	174,785	50,323	366,400	...	591,508
1909	...	4,978	335	13,318	...	18,631
		179,763	50,658	379,718		610,139

MARKING EXPERIMENTS.—During the investigations 16,104 plaice, together with 713 soles and 552 other fish, have been marked and liberated by the Association. Of these, 4605 plaice (28 per cent), 57 soles (8 per cent), and 113 (20 per cent) other fish have been recovered.

The marking experiments made after March, 1909, were intended to cast light on the movements of plaice east of the Dogger Bank, when at a larger size than those marked in the majority of the experiments carried out on the Eastern Grounds. In the month of July 317 plaice were accordingly marked in Clay Deep and the vicinity.

The following table gives the particulars as to the number of plaice recaptured during the period considered:—

Year of Liberation.	Recovered from Ordinary Marking Experiments.	Recovered after transplantation to Dogger Bank.	Recovered after transplantation to Devon Bays.
Prior to June 1, 1906 ...	—	2	—
June 1, 1906, to May 31, 1907	2	20	—
„ 1907 „ 1908	33	99	—
„ 1908 „ 1909	400	355	81
„ 1909 to Mar. 31, 1910	98	—	—
	533	476	81

There have thus been recaptured during the period 1090 plaice. One more of the 23 plaice transplanted from the White Sea on the steam trawler *Princess Louise* has also reached the Laboratory, making 13 of these fish in all.

Vitality Experiments.—The plaice from 16 hauls of the commercial trawl have been subjected to the tests of vitality which have already been described.* In the majority of these experiments some fish were placed in the tanks immediately after capture, others after exposure on deck of one hour. This furnishes information as to the condition of the fish after a period corresponding roughly to that which small plaice would lie on the decks of a commercial trawler before being returned to the sea. It also enables a comparison to be made between the proportion surviving under these conditions and the proportion which would survive if they were at once returned to the sea.

Collection of the Eggs and Larvæ of Fishes.—A voyage was made in June, 1909, for the systematic collection of fish eggs and larvæ in the Southern Bight. The stations were fixed along a series of lines traversing the area several times, an interval of ten miles separating successive stations: at each station a haul of the Hensen net, two hauls of the Petersen small-fish trawl (one near the surface and one near the bottom), and a haul of the Todd trawl were made. The lines of the operation stretched from the Leman Banks to the Haak's Light Vessel, thence to Lowestoft, and so in succession to the Maas, Galloper, North

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* *Internat. Invs. Mar. Biol. Assoc. Report, II,* Pt. II, Cd. 4641, p. 1.

Hinder, and Sandette Light Vessels. D-nets and obliquely hauled tow-nets were also used in the course of the voyage.

Drift Bottles.—In February, 1910, in co-operation with Mr. Bidder, drift bottles were put out along a line stretching E.N.E. from Spurn. One hundred bottom drifters and two hundred and sixty-six surface drifters were put overboard in all, the first at 5 miles and the last at 88 miles from land. This experiment being conducted in an area hitherto untouched in similar investigations, but which is known to be a plaice-spawning ground, should yield results of considerable interest.

The Association is indebted to Messrs. Wilson for granting all facilities for the work, and especially to Capt. French of the s.s. *Zero* for very valuable assistance rendered during the voyage.

B. LABORATORY WORK.

Reports are, or will shortly be, in the press dealing with the Transplantation Experiments, the Marking Experiments, the Age and Growth of Plaice, the Invertebrate Fauna, the Eggs of fishes collected during last June, the Bottom Deposits, the experiments with small-meshed nets covering the commercial trawl, and the Grimsby Trawlers' Records. The materials on which these reports are based have been summarized, and the chief conclusions of many of them mentioned, in previous reports. Some others may be added here.

Transplantation Experiments.—The reports on these experiments take the form of a review of all the results of English experiments carried out between 1904 and 1908. Thirteen of these experiments, dealing with 3942 fish, consisted in the transference of plaice from the coastal grounds of the North Sea to the southern parts of the Dogger Bank. Half the plaice transplanted were between 20 and 23 cm. in length on liberation; from which it will be seen that for the purposes of estimation of growth and percentage recaptured, and of the study of migration, the majority of the experiments must have been closely comparable. By the end of June, 1909, with which month the period covered by the reports ends, nearly a thousand of the plaice had been returned.

The two most noteworthy features of the growth in length of the plaice recovered were the undoubted growth which was found to have occurred on the Bank during the winter months and the ample confirmation afforded of the high estimates of a year's growth derived from the first experiments of the series.* Thus the average growth of the plaice recovered in the March following liberation exceeded that of the fish recaptured in the previous October by over 3 cm. (males 3·1 cm., females 3·9 cm.) in the case of those recaptured on the Bank, and by 1·7 cm. in the case of all recoveries irrespective of position of capture. The first year's growth in length is given in the following table:—

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* Garstang. Expts. in Transplantation, etc. First Report, Southern Area.

Average growth in cm. during one year, drawn from the experiments of 1904–8.

	Total Recoveries.		Recoveries on the Bank.	
	Range of average during the period.	Average of all years combined.	Range of average during the period.	Average of all years combined.
Male	8·7–16·8	12·2	9·8–14·0	11·8
Female	11·0–16·2	14·2	13·1–16·8	15·3
Both sexes combined	9·5–15·4	13·3	10·9–16·8	14·8

Where sufficient data exist for trustworthy comparisons, this growth is found to be never less than twice and frequently from two and a half to three times that prevailing on the coastal grounds from which the plaice were taken. Only a few fish are available for an estimation of growth during *two* years following liberation, but the growth for this period appears to be about 20 cm.

The condition of the transplanted plaice, as indicated by the relation between the weight and the cube of the length of the fish, shows a steady improvement until August, a slackening in September, and a marked increase in October, these relations existing in both the first and second years of liberty. The weight of the plaice retaken after a year was found to have increased to from 4·5 to 5·75 times that possessed on liberation: this increase is, in round terms, rather over three and a half times the increment which would probably have resulted in the same period on the coastal grounds.

Since the value of plaice increases with their size, the increase in value of the transplanted plaice is yet more remarkable. If the most detailed statement of the prices of plaice of different lengths, those drawn up by Johansen for plaice of the Kattegat, be accepted as accurate for the North Sea, it would appear that these plaice when transplanted had a value of £4: within a year £7 worth had been recovered, while those presumably at liberty were of £42 value. Had the plaice remained on the coastal ground, on the same calculation, their total value at the end of the year, assuming none were retaken during the year so that all enjoyed a year's growth, would be but £18. The estimated increase in value in two years is based on more meagre data. It indicates, however, that the value of the plaice retaken within this period was nearly three and a half times (341 per cent) that of all the plaice liberated, while the probable worth of those still at liberty was still greater.

The most marked movement suggested by the position of capture of the transplanted plaice was a spawning migration to the Flamborough Off Ground. As is frequently the case, a greater proportion of the males than of the females appear to travel, more males than females leaving the bank.

Seventy-three per cent of the recaptures were known to be made by English steam trawlers, while of the seventeen per cent which were returned from the Grimsby pontoon or fish markets probably the majority were recovered by the same class of vessel; only seven per cent are known to have been retaken by foreign fishing vessels.

Marking Experiments.—Among the facts brought out by examination of the records of the plaice-marking experiments the following may be mentioned.

The recaptures of plaice marked either on the Flamborough Off Ground or among the Leman Banks were with exceedingly few exceptions confined to a definite tract of ground which follows the main direction of the English coast. Its northern boundary may be said to be 54° N. lat. In the Southern Bight its eastern boundary is 3° E. long., and north of this it is a line trending north-west to the south-western extremity of the Dogger Bank. Practically no plaice were recaptured to the west of a line drawn from Flamborough Head to a few miles east of Cromer. Except in the late spring or early summer very little trawling takes place in this region, and this may account in part for the infrequency of recoveries; but the ground is the typical rough area of the North Sea, and unsuitable for plaice.

On the Flamborough Off and neighbouring grounds the plaice of immature size are markedly stationary, seldom travelling more than a few miles from the point of liberation before they are caught. The mature plaice, on the other hand, travel considerable distances within the above-mentioned limits, in what is clearly a spawning migration. Spawning plaice are taken on the Flamborough Off Ground and in the south of the Southern Bight; spent plaice at these and intermediate positions. The number of mature, spawning, or spent males taken in the Southern Bight is in distinct excess over that of the females, while the reverse is markedly the case on the Flamborough Off Ground. If spent fish are left out of consideration, the above excess of mature males remains; that of females on Flamborough Off Ground remains also, but is very slight. It is thus somewhat uncertain whether a greater proportion of the males than of the females take part in a southward spawning migration, or whether the sexes both move southwards, but the females returning earlier are caught farther to the north than the males.

In the Southern Grounds it is indeed apparent that the females move northwards at an earlier date than the males, the females predominating among the fish of mature size marked near Smith's Knoll, off the Norfolk coast, while the males are in excess in marking experiments farther south.

Experiments on the Eastern Grounds show the annual movements offshore in the summer and inshore in the spring which have already been remarked by many investigators. Practically none of the fish recaptured, however, were of mature size. It is hoped that the experiments of 1909 will cast some light on the movements of mature plaice in this locality.

An observation involving deductions of considerable importance has been made on the fish trawled for marking. The fish are found to differ as to the appearance of the eyes, which are in some cases markedly bright, in others dull. In four experiments particulars of the recoveries of the fish so distinguished have shown that the plaice with bright eyes were recaptured in far greater proportion than the rest. The percentage of the former recovered ranged from 49–54, that of the latter during the same period from 23–34. The eyes therefore would appear to afford a test of the condition of the fish. The high proportion captured in the case of the bright-eyed plaice was fully maintained in two other cases in which only fish of that kind were marked.

The many experiments in which no distinction was made between these classes of plaice uniformly show a lower percentage of recaptures. Thus in forty-nine experiments made during spring in the course of the International Investigations, the percentage recovered only exceeded 40 per cent in five cases, whereas in an experiment made in a worse fishing season 50 per cent of the bright-eyed plaice were retaken in a less number of years. These facts suggest that previous experiments of the intensity of fishing drawn from marking experiments, high though they undoubtedly seemed, were too low. The percentages of recoveries during a year met with among these selected bright-eyed plaice somewhat recall indeed the proportions of Mr. Bidder's bottom-drift bottles returned from fishing vessels.

Eggs and Larvæ of Fishes.—The cruise of the *Huxley* in June, 1909, yielded some important additions to our knowledge of the eggs of many fishes. The eggs occurring in the greatest quantities were those of Mackerel, Sprat, Horse-Mackerel, and Solenette, and the cruise may be said to have considerably advanced our knowledge of the spawning of these species of fish in the Flemish Bight. The great numbers of the eggs of these species which were taken indicate that for these fish June must be a period of intense spawning. In the report on the cruise charts are given showing the distribution of these eggs in the region investigated. Useful results were also obtained from the qualitative hauls—those with the Petersen young-fish trawl and Todd's trawl. The great catches of eggs made with these nets have rendered it possible to obtain clearer views as to the morphological differences between various species which have hitherto been much confused. This has been the case, for instance, with the eggs of Turbot and Greater Weever, Mackerel and Grey Gurnard and Brill. In the report photographs are given showing characteristic differences in these species, and also a mathematical method for distinguishing them, founded on the measurement of groups of eggs and the contained oil-globules. The report contains also a Table of all the catches made with the Hensen net, a discussion of the observations made on the spawning of the sole in the Wash in 1904, and in an appendix, some notes on the Constant of the Hensen net. The distribution of fish larvæ has not been treated, but valuable results should accrue, particularly in the case of the sole-larvæ, from the examination of the great numbers taken with the Petersen trawl. These far exceed any catches hitherto made, and almost every stage of development is represented.

C. FISHERMEN'S RECORDS.

A report on the results obtained from the records of certain Grimsby trawlers has been completed and is now in the press. It contains a detailed analysis of 13,246 hauls made by the skippers of these trawlers, during the period 1904 to 1907, in the central and southern parts of the North Sea, which hauls have been allotted, according to their position, to twenty-three different areas.

The catches of seven species of food fishes are examined, viz. of plaice, soles, turbot, brill, cod, haddock, and whiting, and as far as possible the seasonal and yearly fluctuations of each of these species have been determined for each area. These are measured by monthly averages and illustrated by a series of curves. The importance of each size group (large and small) to the total is considered, and the comparative distribution of each species of fish over the region has been estimated and depicted by charts. The spawning periods and regions are also investigated as far as the records allow.

The final results bring out a striking contrast in the seasonal and geographical distribution of the round and the flat fishes. Plaice, soles, turbot, and brill are all found in their greatest numbers on the eastern grounds and in the areas adjacent to them. In these areas cod and haddock are very scarce, but these species appear to be very abundant on the Dogger Bank and on the grounds north and north-east of it, where the prime fish are very rarely found and plaice are comparatively scarce.

The round fish appear on the inshore and southern grounds in the autumn and winter only, at the time when the flat-fish appear there in very small numbers, and they are almost entirely absent from these same grounds in the late spring and summer, when soles and turbot are numerous.

The yearly fluctuations are variable in their trend, but show on the whole a decline throughout the period for most of the species. The investigation is complicated by the fact that the fluctuations in some areas are complementary to those in others. Compared with records of catches of fish taken ten and twenty-five years before these, they show a very considerable diminution.

An appendix dealing with the factors connecting the rates of fishing per day's absence, per voyage, per haul and per hour, and another giving a short analysis of 1908 records, complete the report.

Section II.—**HYDROGRAPHY.**

During the latter half of the year 1909 the hydrographic programme was the same as in February and May. The special observations during the quarterly cruises were confined to the area lying to the westward of the meridian of Plymouth, and surface samples were collected every fortnight on board cross-channel steamers and a few lightships.

It was not possible to make a hydrographic cruise in February of the present year, but the collection of surface samples was continued up to March 31st, when the English share of the International Investigations was transferred to the Board of Agriculture and Fisheries. A report on the mean conditions in the English and Bristol channels at the times of the quarterly cruises is in preparation.

Published Memoirs.

The following papers, either wholly or in part the outcome of work done at the Laboratory, have been published elsewhere than in the official publications of the Association :—

Drew, G. H.—*Some Notes on Parasitic and Other Diseases of Fish.* Parasitology, vol. 2, No. 3, 1909. *Second Series*, vol. 3, No. 1, 1910.

—— *Some Points in the Physiology of Lamellibranch Blood-Corpuscles.* Quart. Journ. Micr. Sci., vol. 54, 1910, pp. 605–21.

—— *The Reproduction and Early Development of Laminaria digitata and Laminaria saccharina.* Annals of Botany, vol. 24, 1910, pp. 177–90.

DUNKERLY, J. S. *Note on Our Present Knowledge of the Choanoflagellata.* Journ. Quekett Micro. Club, April, 1910, pp. 19–24.

ISGROVE, A. *Eledone.* L.M.B.C. Memoirs. XVIII. 1909.

SEXTON, E. W. On the Amphipod genus *Trischizostoma.* Proc. Zool. Soc., 1908, pp. 370–402.

—— *Notes on some Amphipoda from the North Side of the Bay of Biscay. Families, Pleustidae and Eusiridae.* Proc. Zool. Soc., 1909, pp. 848–79.

Donations and Receipts.

The receipts for the year for the ordinary work of the Association include the grants from His Majesty's Treasury (£1000), and the Worshipful Company of Fishmongers, paid in advance during the financial year 1908–09 (£400), Special Donations (£264), Annual Subscriptions (£85), Rent of Tables in the Laboratory (£61), Sale of Specimens (£429), Admission to Tank Room (£139).

The following is a list of the Special Donations:—

	£	s.	d.
Sir John Murray, K.C.B., F.R.S. . .	100	0	0
E. J. Schuster, Esq. . . .	50	0	0
A. E. Shipley, Esq., D.SC., F.R.S. . .	50	0	0
W. I. Beaumont, Esq. . . .	25	0	0
Edgar Schuster, Esq., D.SC. . . .	25	0	0
A. O. Walker, Esq. . . .	10	0	0
Mrs. Weldon	3	3	0
F. F. Blackman	1	1	0
	264	4	0

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1910–11:—

President.

Sir E. RAY LANKESTER, K.C.B., LL.D., F.R.S.

Vice-Presidents.

The Duke of ABERCORN, K.G., C.B.
The Duke of BEDFORD, K.G.
The Earl of ST. GERMANS.
The Earl of DUCIE, F.R.S.
The Earl of STRADBROKE, C.V.O., C.B.
Lord AVEBURY, F.R.S.
Lord WALSINGHAM, F.R.S.
The Right Hon. A. J. BALFOUR, M.P., F.R.S.
The Right Hon. JOSEPH CHAMBERLAIN, M.P.
The Right Hon. AUSTEN CHAMBERLAIN, M.P.
G. A. BOULENGER, Esq., F.R.S.
A. C. L. GÜNTHER, Esq., F.R.S.
Sir JOHN MURRAY, K.C.B., F.R.S.
Rev. Canon NORMAN, D.C.L., F.R.S.
EDWIN WATERHOUSE, Esq.

Members of Council.

G. L. Alward, Esq.
W. T. Calman, Esq., D.Sc.
Prof. A. Dendy, D.Sc., F.R.S.
Sir Charles Eliot, K.C.M.G.
G. Herbert Fowler, Esq., Ph.D.
Prof. F. W. Gamble, D.Sc., F.R.S.
S. F. Harmer, Esq., Sc.D., F.R.S.
Commander M. W. Campbell Hepworth, C.B., R.N.R.
E. W. L. Holt, Esq.
J. J. Lister, Esq., F.R.S.
Prof. E. W. MacBride, F.R.S.
P. Chalmers Mitchell, Esq., D.Sc., F.R.S.
Edgar Schuster, Esq., D.Sc.
Prof. D'Arcy W. Thompson, C.B.

Chairman of Council.

A. E. Shipley, Esq., D.Sc., F.R.S.

Hon. Treasurer.

J. A. Travers, Esq., Tortington, Arundel.

Hon. Secretary.

E. J. Allen, Esq., D.Sc., The Laboratory, Citadel Hill, Plymouth.

The following Governors are also members of the Council:—

G. P. Bidder, Esq., M.A.
Hugh C. Smith, Esq. (Prime Warden of the Fishmongers' Company).
Bryan Durant, Esq. (Fishmongers' Company).
Sir Richard Martin, Bart. (Fishmongers' Company).
Prof. G. C. Bourne, D.Sc., F.R.S. (Oxford University).
A. E. Shipley, Esq., D.Sc., F.R.S. (Cambridge University).
Prof. W. A. Herdman, D.Sc., F.R.S. (British Association).

STATEMENT OF RECEIPTS AND PAYMENTS

FOR THE YEAR ENDING 31st MAY, 1910.

Dr.

Statement of Receipts and Payments for

	£	s.	d.	£	s.	d.
To Balance from last year, viz. :—						
Cash at Bank	713	10	3			
Cash in hand	14	2	3			
	727	12	6			
Less Loan due to Bank	500	0	0	227	12	6
,, Current Income :—						
H.M. Treasury	1,000	0	0			
Annual Subscriptions	85	0	0			
Rent of Tables	61	9	0	1,146	9	0
,, Extraordinary Receipts :—						
Donations, per Report				264	4	0
,, Charter of Steamboats :—						
S.S. *Huxley*, for period 25th June, 1909, to 31st March, 1910				662	9	2
,, Sale of s.s. *Huxley* :—						
W. Crampin	2,400	0	0			
Less Commission on Sale	60	0	0	2,340	0	0
				£4,640	14	8

Examined and found correct.

(Signed) N. E. Waterhouse. Arthur Dendy.

P. Chalmers Mitchell. L. W. Byrne.

29th June, 1910.

the *Year ending* 31*st May*, 1910. **Cr.**

		£ s. d.	£ s. d.
By Current Expenditure:—			
Salaries and Wages—			
Director		200 0 0	
Assistant Director		196 13 4	
Naturalist		175 0 0	
Salaries and Wages, and Compensation paid		718 14 5	
		1,290 7 9	
Less Compensation recovered from Employers Liability Assurance Corporation		27 8 9	1,262 19 0
Travelling Expenses			35 1 2
Library			133 6 1
Journal		72 1 9	
Less Sales of Journal		9 4 4	62 17 5
Buildings and Public Tank Room—			
Gas, Water, and Coal		110 13 9	
Stocking Tanks and Feeding		43 3 1	
Maintenance and Renewals		96 3 1	
Rent of Land, Rates, Taxes, and Insurance		36 3 4	
		286 3 3	
Less Admission to Tank Room		139 2 5	147 0 10
Laboratory, Boats, and Sundry Expenses—			
Stationery, Office Expenses, Printing, etc.		155 11 8	
Glass, Apparatus, and Chemicals	171 2 11		
Less Sales	83 1 3	88 1 8	
Purchase of Specimens		65 15 11	
Maintenance and Renewals of Boats, Nets, Gear, etc., exclusive of s.s. *Huxley*	196 2 9		
Less Sales	5 10 3	190 12 6	
Insurance of Steamers—			
S.S. *Huxley*	139 16 6		
S.S. *Oithona*	22 14 6	162 11 0	
Coal and Water for Steamers, excluding s.s. *Huxley*		76 0 6	
		738 13 3	
Less Sale of Specimens		429 10 3	309 3 0
By Bank Interest			9 0 10
" Extraordinary Expenditure:—			
Purchase of s.s. *Huxley*—			
Balance of Mortgage, including interest and charges paid to Mr. G. P. Bidder			1,937 16 6
By Balance, including balance of Special Grant of £500 received last year, applicable to the year ending 31st May, 1911:—			
Cash at Bank		1,033 12 2	
Cash in hand		9 17 8	
		1,043 9 10	
Less Bank Loan		300 0 0	743 9 10
This Balance is apportioned as follows:—			
General Account	543 9 10		
Repairs and Renewals	200 0 0		
	743 9 10		
			£4,640 14 8

NOTE.—Under the terms of a Deed, dated 9th November, 1907, and made between the Association and Mr. G. P. Bidder, a sum of approximately £750, in respect of the sale of the s.s. *Huxley*, was on the 31st May, 1910, held for such purposes as Mr. Bidder should designate. This sum has since been handed over to Trustees nominated by Mr. Bidder.

Marine Biological Association of the United Kingdom.

LIST
OF
Governors, Founders, and Members.

1st JULY, 1910.

* Member of Council. † Vice-President. ‡ President.

Ann. signifies that the Member is liable to an Annual Subscription of One Guinea.

C. signifies that he has paid a Composition Fee of Fifteen Guineas in lieu of Annual Subscription.

I.—Governors.

The British Association for the Advancement of Science, *Burlington House, W.*	£500
The University of Oxford	£500
The University of Cambridge	£500
The Worshipful Company of Clothworkers, 41, *Mincing Lane, E.C.*	£500
The Worshipful Company of Fishmongers, *London Bridge, E.C.*	£9405
Bayly, Robert (the late)	£1000
Bayly, John (the late)	£600
Thomasson, J. P. (the late)	£970
G. P. Bidder, Esq., *Cavendish Corner, Cambridge*	£1400

II.—Founders.

1884	The Corporation of the City of London	£210
1884	The Worshipful Company of Mercers, *Mercers' Hall, Cheapside*	£341 5*s.*
1884	The Worshipful Company of Goldsmiths, *Goldsmiths' Hall, E.C.*	£100
1884	The Royal Microscopical Society, 20, *Hanover Square, W.*	£100
1884	The Royal Society, *Burlington House, Piccadilly, W.*	£350
1884	The Zoological Society, *Regent's Park, London, N.W.*	£100
1884	Bulteel, Thos. (the late)	£100
1884	Burdett-Coutts, W. L. A. Bartlett, 1, *Stratton Street, Piccadilly, W.*	£100
1884	Crisp, Sir Frank, Treas. Linn. Soc., 17, *Throgmorton Avenue, E.C.*	£100
1884	Daubeny, Captain Giles A., *The Vicarage, Tottington, Bury, Lancs.*	£100
1884	Eddy, J. Ray, *The Grange, Carleton, Skipton*	£100
1884	Gassiott, John P. (the late)	£100
‡1884	Lankester, Sir E. Ray, K.C.B., F.R.S., 29, *Thurloe Place, South Kensington, S.W.*	£100

1884	The Rt. Hon. Lord Masham (the late)	£100
1884	Moseley, Prof. H. N., F.R.S. (the late)	£100
†1884	The Rt. Hon. Lord Avebury, F.R.S., *High Elms, Bromley, Kent*	£100
1884	Poulton, Prof. Edward B., M.A., F.R.S., *Wykeham House, Oxford*	£100
1884	Romanes, G. J., LL.D., F.R.S. (the late)	£100
1884	Worthington, James (the late)'	£100
1885	Derby, the late Earl of	£100
1887	Weldon, Prof. W. F. R., F.R.S. (the late)	£100
1888	Bury, Henry, M.A., *Mayfield House, Farnham, Surrey*	£100
1888	The Worshipful Company of Drapers, *Drapers' Hall, E.C.*	£315
1889	The Worshipful Company of Grocers, *Poultry, E.C.*	£120
1889	Thompson, Sir Henry, Bart. (the late)	£110
1889	Revelstoke, The late Lord	£100
1890	Riches, T. H., B.A., *Kitwells, Shenley, Herts*	£230
1902	Gurney, R., *Ingham Old Hall, Stalham, Norfolk*	£105
1909	Harding, Colonel W., *The Hall, Madingley, Cambridge*	£100
†1910	Murray, Sir John, K.C.B., F.R.S., *Challenger Lodge, Wardie, Edinburgh*	£100

III.—Members.

1897	Adams, W. R., 16, *Milestone Road, Cintra Park, Upper Norwood, London*	Ann.
1900	Aders, W. M., 3, *Hall Road, London, N.W.*	Ann.
1884	Alger, W. H., 8, *The Esplanade, Plymouth*	*C.*
*1895	Allen, E. J., D.Sc., *The Laboratory, Plymouth*	Ann.
*1889	Alward, G. L., *Enfield Villa, Humberstone Avenue, Waltham, Grimsby*	Ann.
1892	Assheton, R., M.A., *Riversdale, Grantchester, Cambridge*	£20
1902	Baker, R. J., 3, *Ash Villas, Collings Park, Mannamead, Plymouth*	Ann.
1884	Balfour, Prof. Bayley, F.R.S., *Royal Botanic Gardens, Edinburgh*	*C.*
1908	Ballard, Edward, *Greenfield, Hoole Village, Chester*	Ann.
1884	Bayliss, W. Maddock, D.Sc., F.R.S., *St. Cuthberts, West Heath Road, Hampstead*	Ann.
1884	Bayly, Miss, *Seven Trees, Plymouth*	£50
1884	Bayly, Miss Anna, *Seven Trees, Plymouth*	£50
1884	Beaumont, W. I., B.A., *The Laboratory, Plymouth*	Ann.
1885	Beck, Conrad, 68, *Cornhill, E.C.*	*C.*
1887	Beddard, F. E., F.R.S., *Zoological Society's Gardens, Regent's Park, N.W.*	Ann.
1884	Beddington, Alfred H., 8, *Cornwall Terrace, Regent's Park, N.W.*	*C.*
†1907	Bedford, His Grace the Duke of, K.G., *Endsleigh, Tavistock*	*C.* & Ann. £10 10s.
1903	Bidder, H. F., 10, *Queen's Gate Gardens, London, S.W.*	Ann.
1910	Bidder, Mrs. M. G., *Cavendish Corner, Cambridge*	Ann.
1910	Borley, J. O., M.A., 43, *Parliament Street, London, S.W.*	Ann.
*1884	Bourne, Prof. Gilbert C., M.A., F.R.S., *Savile House, Mansfield Road, Oxford*	Ann.
1910	Bowkett, Sidney, *Claygate, Surrey*	Ann.
1898	Bowles, Col. Henry, *Forty Hall, Enfield*	Ann.
1910	Bradford, J. Rose, M.D., D.Sc., F.R.S., 8, *Manchester Square, London, W.*	Ann.
1910	Bridgman, F. J., *Royal College of Science, South Kensington, S.W.*	Ann.
1902	Brighton Public Library (Henry D. Roberts, Chief Librarian)	Ann.
1886	Brooksbank, Mrs. M., *Leigh Place, Godstone, Surrey*	*C.*

1884 Brown, Arthur W. W., 62, _Carlisle Mansions, Carlisle Place, London, S.W._ C.
1910 Brown, F. J., 10, _Belmont Road, Ilfracombe_............ Ann.
1893 Browne, Edward T., B.A., _Anglefield, Berkhamsted_ .... Ann.
1910 Brown, Mrs. E. T., _Anglefield, Berkhamsted_............ Ann.
1897 Byrne, L. W., B.A., 7, _New Square, Lincoln's Inn, London, W.C._......... Ann.

*1908 Calman, Dr. W. T., _British Museum (Natural History), Cromwell Road, S.W._............ Ann.
†1884 Chamberlain, Rt. Hon. J., M.P., 40, _Prince's Gardens, S.W._ .... Ann.
1884 Christy, Thomas Howard, 199, _Bramhall Lane, Stockport_...... .... C.
1910 Clarke, G. B. R. Kitson, _Meanwoodside, Leeds_ .... Ann.
1887 Clarke, Rt. Hon. Sir E., K.C., 5, _Essex Court, Temple, E.C._............ £25
1885 Clerk, Major-General H., F.R.S., "_Mountfield_," 5, _Upper Maze Hill, St. Leonards-on-Sea, Sussex_ £21
1886 Coates and Co., _Southside Street, Plymouth_ .... C.
1885 Collier Bros., _Old Town Street, Plymouth_............ C.
1900 Cooper, W. F., B.A., _Ashlyns Hall, Berkhamsted_............ Ann.
1909 Crawshay, L. R., M.A., _The Laboratory, Plymouth_ .... Ann.

1910 Darbishire, A. D., M.A., _Imperial College of Science and Technology, South Kensington, S.W._............ Ann.
1885 Darwin, Francis, F.R.S., 13, _Madingley Road, Cambridge_............ C.
1885 Darwin, W. E., _Ridgemount Bassett, Southampton_ £20
*1908 Dendy, Prof. A., F.R.S., _Binfield, Weybridge_ .... Ann.
1884 Dewick, Rev. E. S., M.A., F.G.S., 26, _Oxford Square, Hyde Park, W._ ... C.
1885 Dixey, F. A., M.A. Oxon., _Wadham College, Oxford_ ....£26 5_s. and_ Ann.
1906 De Morgan, W. C., _c/o National Provincial Bank, Plymouth_............ Ann.
1910 Dobell, C. C., _Imperial College of Science and Technology, South Kensington, S.W._ .... Ann.
1910 Drew, G. H., B.A., _The Laboratory, Plymouth_............ Ann.
1890 Driesch, Hans, Ph.D., _Philosophenweg_ 5, _Heidelberg, Germany_ .... C.
†1889 Ducie, The Rt. Hon. the Earl of, F.R.S., _Tortworth Court, Falfield, R.S.O._ £50 15_s._
1884 Dunning, J. W., 4, _Talbot Square, London, W._............£26 5_s._
1884 Dyer, Sir W. T. Thiselton, M.A., K.C.M.G., F.R.S., _The Ferns, Witcombe, Gloucester_............ C.

*1898 Eliot, Sir C. N. E., K.C.M.G., C.B., _Endcliffe Holt, Endcliffe Crescent, Sheffield_ ....Ann. £5
1906 Elliott, Sir Thomas H., K.C.B., _Board of Agriculture and Fisheries,_ 4, _Whitehall Place, London, S.W._ .... Ann.
1908 Elwes, Maj. Ernest V., _Glendower, St. Albans Road, Babbacombe_ .... Ann.
1893 Enys, John Davies, _Enys, Penryn, Cornwall_ .... Ann.
1885 Ewart, Prof. J. Cossar, M.D., _University, Edinburgh_ £25

1894 Ferrier, David, M.A., M.D., F.R.S., 34, _Cavendish Square, W._............ Ann.
1884 Fison, Sir Frederick W., Bart., 64, _Pont Street, London, S.W._............ C.
1897 Foster, Richard, _Windsworth, Looe, R.S.O._ .... Ann.
*1885 Fowler, G. Herbert, B.A., Ph.D., _The Old House, Aspley Guise, Bedfordshire_ .... Ann.
1884 Fox, George H., _Wodehouse Place, Falmouth_ .... Ann.
1884 Fry, George, F.L.S., _Carlin Brae, Berwick-on-Tweed_ £21

1892	Galton, F., F.R.S., 42, *Rutland Gate, S.W.*	Ann.
*1907	Gamble, Prof. F. W., D.Sc., F.R.S., 38, *Frederick Road, Edgbaston, Birmingham*	Ann.
1906	Gardiner, Prof. J. Stanley, M.A., F.R.S., *Caius College, Cambridge*	Ann.
1907	Garstang, Prof. W., D.Sc., 2, *Ridge Mount, Cliff Road, Headingly, Leeds*	Ann.
1885	Gaskell, W. H., F.R.S., *The Uplands, Shelford, Cambridge*	*C.*
1901	Giles, Col. G. M., 3, *Elliot Terrace, Plymouth*	*C.*
1885	Gordon, Rev. J. M., *St. John's Vicarage, Redhill, Surrey*	Ann.
1884	Grove, E., *Norlington, Preston, Brighton*	Ann.
1899	Guinness, Hon. Rupert, *Elveden, Thetford*	£35 15*s.*
†1884	Günther, Dr. Albert, F.R.S., 2, *Lichfield Road, Kew Gardens*	Ann.
1900	Gurney, E., *Sprowston Hall, Norwich*	Ann.

1884	Halliburton, Prof. W. D., M.D., F.R.S., *Church Cottage*, 17, *Marylebone Road, London, W.*	Ann.
1909	Hamilton, Dr. G. C., 21, *Finsbury Circus, London, E.C.*	Ann.
1884	Hannah, Robert, 82, *Addison Road, Kensington, W.*	*C.*
*1885	Harmer, S. F., D.Sc., F.R.S., *British Museum (Natural History), Cromwell Road, S.W.*	*C.*
1889	Harvey, T. H., *Cattedown, Plymouth*	Ann.
1888	Haselwood, J. E., 3, *Lennox Place, Brighton*	*C.*
1884	Haslam, Miss E. Rosa, *Ravenswood, Bolton*	£20
1884	Head, J. Merrick, F.R.G.S., J.P., *Pennsylvania Castle, Isle of Portland, Dorset*	Ann.
1884	Heape, Walter, *Greyfriars, Southwold, Suffolk*	*C.*
1910	Hefford, A.E., B.Sc., 43, *Parliament Street, London, S.W.*	Ann.
*1908	Hepworth, Commander M.W. Campbell, C.B., R.N.R., *Meteorological Office*, 63, *Victoria Street, London, S.W.*	Ann.
*1884	Herdman, Prof. W. A., F.R.S., *The Zoology Department, The University, Liverpool*	Ann.
1884	Herschel, Col. J., R.E., F.R.S., *Observatory House, Slough, Berks.*	*C.*
1889	Heywood, Mrs. E. S., *Light Oaks, Manchester*	*C.*
1910	Hicks, F., *Zoological Laboratory, King's College, London, W.C.*	Ann.
1884	Hickson, Prof. Sydney J., M.A., D.Sc., F.R.S., *Ellesmere House, Wilenslow Road, Withington, Manchester*	Ann.
1910	Hill, Dr. Alex., *Royston, Herts*	Ann.
1907	Hill, Prof. J. P., *The Zoological Laboratory, University College, London. W.C.*	Ann.
1897	Hodgson, T. V., 54, *Kingsley Road, Plymouth*	Ann.
*1905	Holt, E. W. L, 46, *Lower Baggot Street, Dublin*	Ann.
1909	Hoyle, W. E., M.A., D.Sc., *National Museum of Wales, City Hall, Cardiff*	Ann.

1891	Indian Museum, *Calcutta*	Ann.
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BY

J. T. CUNNINGHAM, M.A.,

FORMERLY FELLOW OF UNIVERSITY COLLEGE, OXFORD;
NATURALIST ON THE STAFF OF THE MARINE BIOLOGICAL ASSOCIATION.

With Preface by

E. RAY LANKESTER, M.A., LL.D., F.R.S.,

PROFESSOR OF COMPARATIVE ANATOMY IN THE UNIVERSITY OF OXFORD.

Preliminary Notice on the Experimental Hybridization of Echinoids.

By

Cresswell Shearer, Walter De Morgan and **H. M. Fuchs.**

With 7 Text Figures.

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I. Introduction and Previous Work.

THIS paper is a preliminary account of a series of experiments on the hybridization of Echinoids, first commenced by one of our number (De Morgan) at Plymouth in 1909, and which will form part of a larger work now approaching completion. This will comprise the hybridization of *Echinus acutus*, *E. esculentus*, and *E. miliaris*, together with an account of the cytology of the hybrid crosses and the control of paternal and maternal influence by chemical means.*

Within the last two decades a large amount of attention has been devoted to the problem of parental influence in Echinoderm hybrids. Most of this work has been done at Naples, where the majority of sea-urchins seem to possess a longer breeding period than those of the colder waters of our own coasts. In America within the last year or two considerable attention has been devoted to this subject. In the hands of different observers, however, this work has led to very conflicting results, and has proved most indecisive in settling the main points at issue.

In 1889 Boveri (3) was the first to investigate the hybrids between different Echinoids, making use of *Sphaerechinus* eggs and *Echinus* sperms at Naples. He found that the hybrid larvæ were intermediate between those of the two parents. In 1894 Seeliger (16) made the same cross at Trieste, but found that many of his hybrids were of the purely paternal type; thus contradicting Boveri's result. In the following year Morgan (12) repeated this work, getting the same results as Seeliger. In 1895 Boveri (4) replied to Seeliger and Morgan substantiating his earlier results, but suggesting that at Trieste the Plutei had other characteristics from those at Naples. This does not apply, however, to Morgan's results obtained at Naples on the same material as that used by Boveri.

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* The full paper will contain a large number of skeleton figures and drawings of Plutei and coloured plates of the hybrid urchins. The investigation of the cytology has been undertaken by L. Doncaster, and will form Part II of the paper.

In the same year Vernon (19) commenced a new era in the work by a thorough investigation of the effects of environment on the larvæ. In 1898 he followed up his first work with the investigation of inheritance in various hybrid forms. He made crosses between *Sphaerechinus*, *Strongylocentrotus* and *Echinus*. His hybrid larvæ were mostly maternal, but some species seemed to have a greater capacity for transmitting their characteristics than others. In the same year Driesch (6) crossed *Strongylocentrotus*, *Sphaerechinus*, *Echinus*, and *Arbacia* and obtained hybrid larvæ of a purely maternal type.

In 1900 Vernon (21) hybridized *Strongylocentrotus* and *Sphaerechinus* at Naples and claimed to find that the parental influence in the resulting hybrids varied with the season of the year at which the experiments were made. In spring they resembled *Strongylocentrotus*, while in summer they were like *Sphaerechinus*. In the latter case, however, none of the larvæ were of the pure *Sphaerechinus* type. He suggested that this variation was due to a seasonal fluctuation in the relative ripeness of the sexual products.

In 1902 Steinbrück (17) studied the cross *Strongylocentrotus* ♂ × *Sphaerechinus* ♀ and came to the conclusion that, while there was a seasonal variation in dominance, it was not due to the relative ripeness of the eggs and sperm, but to changes in temperature; for, by raising the temperature of the water in which his larvæ were kept, in the spring he caused them to assume the summer form. In the same year Driesch (7) did some further work on the hybridization of *Strongylocentrotus*, *Sphaerechinus*, and *Echinus*, and substantiated his earlier results of maternal influence.

In 1906 Fischel (8) working at Villefranche, crossed *Arbacia*, *Echinus*, and *Strongylocentrotus* and contradicted Driesch, finding that the sperm had an important influence and that the hybrids showed undoubted paternal characters, although these were, he admitted, of a very minor degree as compared with the maternal.

In 1909 Hagedoorn (9), working in Loeb's Laboratory, Pacific Grove, Cal., crossed *Strongylocentrotus purpuratus* and *S. franciscanus* and found a purely motherly dominance in the shapes of the skeletal apical rods. In the following year Loeb, King, and Moore (10) repeated these experiments at the same place, but reached very different results. They came to the conclusion that each character was inherited separately, that is, quite apart from whether it is of maternal or paternal origin: that of a pair of allelomorphic characters one is invariably dominant over the other in the hybrid: that the characters of the Pluteus are inherited on strictly Mendelian lines. Thus, for instance, they found the club-shaped ends of the skeletal rods to be dominant over the arched form, the round, dome-shape of the larvæ to be dominant over the pyramidal, the rough spinous character of the skeletal rods dominant over the smooth, and so on through a number of characters. They made no attempt to rear their larvæ to metamorphosis and to follow these characters in the later stages, neither did they attempt to trace, if possible, the characters in the later generations, in the usual Mendelian manner.

Lastly, Tennent (18) working at the Tortugas Laboratory, off the coast of Florida, in the midst of the warm water of the Gulf Stream, crossed among other forms *Toxopneustes* and *Hipponöe*, always finding his hybrids to resemble *Hipponöe*. He then altered the concentration of the OH-ions in the seawater in which the cross was made, and found by this means that the dominance was changed to the *Toxopneustes* side. Here again, as in all the previous work, it is doubtful if characters sufficiently definite have been adopted as an index of parental influence. For instance, the skeletal support of the post-oral arm of *Toxopneustes* is a single rod, whereas in *Hipponöe* it is a lattice structure. If, in his hybrids, more than one rod appeared in the arm, Tennent considered it as an indication of *Hipponöe* influence. But as previous observers have noted, and we have repeatedly found in our own experiments, extra rods appear, under unfavourable conditions, even in forms which do not normally possess them.

From the above brief review of the subject, it is plain that the opinions expressed by the different investigators have been most conflicting, and that the conclusions they have drawn have been, in many instances, diametrically opposite to one another, although the work was frequently done with the same material. This is in great part due to the uncertain nature of the evidence on which these results have been based, evidence which has been drawn from the early development alone. No successful attempt has been made to rear the hybrids, in order to follow the nature of the parental influence in the later and less variable stages. The chief index of paternal or maternal influence has been the skeleton; but this, unfortunately, exhibits a large amount of irregular variation dependent on small metabolic changes, a variation in many cases quite independent of heredity.

The present work was commenced, therefore, with the object of discovering fixed specific characters, into which we felt certain no irregular variation entered. After considerable investigation we came to the conclusion that these could only be looked for in the later period of larval life. For in our experiments we have found that every culture jar had its own rate of development and showed minor variations with regard to the early larval characters, such as skeleton, pigmentation, and shape, so that it was plain that no definite results could be hoped for from the investigation of young stages alone.

Thanks to the methods elaborated by Dr. Allen (1) of rearing marine larvæ and of feeding them on pure cultures of diatoms from which bacteria and infusoria are as far as possible eliminated, and of keeping the larvæ in sterilized sea-water, it is now possible to rear the Plutei of Echinoids with great facility through metamorphosis to the young fully formed Sea-Urchin.* This suggested to us the idea of making a full investigation of the later stages of the pure and hybrid forms, and we hope to show that we have found in them immutable and distinct specific characters which give much more definite evidence than those hitherto used in this work.

We have chosen *Echinus acutus*, *E. esculentus*, and *E. miliaris* as the three commonest forms on our coasts, and also for the reason that we already possess in MacBride's work (1) a clear account of the main features of the normal development of these species. Of these three forms, *E. acutus* and *E. esculentus* at Plymouth are found in deeper water, while *E. miliaris* is a shore species. It is therefore highly probable that laboratory conditions are more favourable to the latter than to the two former; and this would seem to be borne out by the fact that *E. miliaris* develops, under laboratory conditions, much more quickly than the other two, and that in all crosses into which *E. miliaris* enters the rate of development is accelerated.

While there are marked specific differences between *E. miliaris*† (which has by some authors been placed in a separate genus, *Par-*

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* While previous investigators have unsuccessfully attempted to rear hybrid Plutei through metamorphosis, Doncaster (5), making use of the cross *Strongylocentrotus lividus* ♂ × *Echinus microtuberculatus* ♀, seems to have been the first to have accomplished this. One of the present authors (Shearer) had the opportunity in 1902 of examining these hybrids at Naples.

† It may be here noted that *E. miliaris*, on the Devonshire coast, exhibits several distinct varieties, which differ chiefly in size, in length of spines, and in pigmentation.

echinus) and *E. esculentus* or *E. acutus*, there is much less distinction between the two latter, which we suspect to be merely varieties of one and the same species, although according to Bell (2) the number and disposition of the plates differ considerably. We were quite unable, from a superficial examination, to tell to which species a large number of specimens, brought into the laboratory during the course of our experiments, belonged. In shape and character of their spines they were as much *E. esculentus* as *E. acutus*, and without a close examination of their plates it was quite impossible to identify them.

In the "Ingolf" Echinoidea I (14), Mortensen mentions some specimens, which "combine to a curious degree the character of both *E. esculentus* and *acutus*, var. *Flemingii*, so that it is quite impossible to decide with certainty to which of these species they belong, and the supposition of their being hybrids between the two species seems very obvious." In his recent paper (15) he gives a photograph of one of these supposed hybrids, with a description. We ourselves have long suspected that such hybridization must take place between *E. esculentus* and *E. acutus* at Plymouth, where they live side by side on the same beds, their breeding periods overlapping very considerably. If crossing between these two forms is such an easy matter in the laboratory, why should it not take place in a state of Nature? This is a question that has also been raised by Doncaster (5). We believe that considerable hybridization does take place, and the forms to which we have drawn attention above, and which agree in many respects with the one figured by Mortensen (15), seem to bear out this conclusion. In our full paper we shall give photographs and go into details of the plates of these intermediate forms.

Mortensen (15) also gives a figure of a form which he considers to be a cross between *E. esculentus* and *E. miliaris*. We have already mentioned in a footnote, page 124, that there are several varieties of *E. miliaris* at Plymouth, and one of these bears a considerable resemblance to Mortensen's supposed hybrid. This variety differs, however, in the character of its spines from the young hybrids of this cross which we have reared.

We have been unable to detect differences between the larvæ of *E. esculentus* and *E. acutus*, except that the skeletal apical rods of the latter are more robust and less arched than those of the former. For this reason, in the present paper, we have not considered in any detail the development of *E. acutus*, beyond pointing out that, when crossed with *E. miliaris*, it behaves similarly to *E. esculentus*. In our forthcoming paper we will go into these points in full.

We have tried to eliminate from our cultures, as far as possible, all abnormal or unhealthy Plutei. No drawings or observations have been made of any such larvæ, and all crosses showing an unusually large percentage of abnormalities have been thrown away and the experiments repeated. It is remarkable, however, how frequently abnormalities, especially with regard to the development of the arms and skeleton, are to be seen in Plutei taken from the Plankton.

Although we have had no difficulty in rearing Plutei in considerable numbers through metamorphosis, and some of our young hybrid urchins are now, after two years, one centimetre in diameter,* we have not succeeded so far in bringing them to a stage of sexual maturity. This is doubtless due to the fact that we have been unable to furnish them with the proper food. For it would seem, from what we have been able to discover regarding *E. miliaris*, that individuals of this species at least can become sexually mature within the first year of their existence, in a state of nature, and can attain the size of some six centimetres. As none of the *E. miliaris* hybrids in our cultures in the laboratory have shown any such rapid rate of growth, we feel that we have only partially succeeded in our feeding methods.

During the first few weeks after metamorphosis the young Echini thrive readily on the "red weed" (*Delesseria*), but after this they soon cease to grow, and evidently at this stage a further change of food is necessary. What exactly this change should be we have so far been unable to find out, and we have simply allowed them to remain in culture jars in the hope that they will find their proper food among the algae growing there.

It is the ultimate object of our work to bring the hybrid urchins to sexual maturity and, if possible, investigate the characters of the second generation. Our experiments of the last three years seem to point to the improbability of accomplishing this under laboratory conditions, and we are at present devising a method for confining our young hybrid urchins on the sea bottom in their natural habitat.

It is obvious, however, that all laboratory conditions differ in many essentials from those obtaining in nature. For this reason we have, this year, raised Plutei from the first in the sea, by confining them in jars in the chambers of a floating box, which is anchored some miles out, in the clearer water of Plymouth Sound. We have not noticed that our Plutei reared under these conditions grow more rapidly than those kept in the Laboratory, and this would seem to be due to the lack of food. It seems to be impossible to get any protected water where the Plutei might be confined, as rich in the Diatom flora as that of the rapidly changing tidal waters that sweep over the beds where the Echini find their natural habitat. Nevertheless a number of the Plutei reared under these conditions have metamorphosed.

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* One hybrid, raised at Cambridge, is now 3 cm. in diameter. For figures of same, *vide Nature*, Vol. LXXXVII, p. 111, 1911.

II. MATERIAL.

The experiments were commenced in the Laboratory of the Marine Biological Association, Plymouth, in 1909, and continued through 1910 and 1911. Similar results were obtained from each series of experiments.

Echinus esculentus and *E. acutus* are obtainable at Plymouth in fairly large quantities by trawling in depths of about 25 fathoms.

Echinus miliaris is a shore species. It is not so numerous as the other species, and can only be collected at very low tides.

The percentage of ripe Echini in a haul is small. The quantity of material consumed was consequently large, and our thanks are due to Dr. Allen and the staff of the Laboratory for the trouble taken to provide us with a constant supply of material.

To ensure successful fertilization it is essential that the sperm and ova should be thoroughly mature. Partially ripe sperm and ova are capable of fertilizing, and of being fertilized, but the larvæ of such a union do not develop normally, and seldom reach a late stage, although they may remain alive for many days.

It might be assumed that the ideal condition would be to use Echini on the point of discharging their genital products, and such under normal conditions would be correct, but we have frequently noticed that under irritation or when in an unhealthy condition the animals discharge their sperm and ova. In a few instances we have observed them discharging in vast quantities when in a moribund condition, the urchins dying afterwards within a few hours. It is almost unnecessary to add that, when eggs or sperm, shed in this manner, are brought together, fertilization either fails to take place, or the resulting Plutei are abnormal and unhealthy.

If a ripe ovary is gently shaken in water, the ova will float away without any or but a small quantity of follicular tissue. Rough shaking should be avoided, as by it many partly ripe and immature eggs will be detached. The ovary from which the greatest number of eggs is obtained with the least agitation, and the least admixture of the tissue, will generally be found to give the best result. Under the microscope the nuclei of such eggs will not be visible.

It is more difficult to judge the ripeness of the spermatozoa, as they are motile some time before they are actually mature. The mature male gonad when torn exudes a milky fluid, which under the microscope appears to seethe with vibratile spermatozoa; but it is obviously difficult to compare the relative rapidity of motion in sperms from different individuals.

III. METHODS.

A portion of a ripe ovary was placed in a finger bowl containing either "outside water" or "Berkefeld water."*

As soon as the ova floated out, the piece of ovary and any pieces of tissue were removed and a small quantity of a culture of sperm added. Excess of sperm should be avoided, as it speedily fouls the water, which should be changed if it appears milky. If sperm and ova were ripe, the fertilization membrane was thrown out in a few minutes, and segmentation followed. In about twenty-four hours free-swimming blastulae appeared. These were removed to jars containing about 2000 cc. of Berkefeld or outside water. A couple of small pipettes-full of a culture of the diatom *Nitschzia closterium* were then added for food, and the blastulae left to develop.

All the usual precautions for sterilizing jars, pipettes, scissors, etc., were rigidly observed, and before being opened the Echini were immersed in tap water to destroy any sperm adhering to the test. In all experiments proper controls were kept, and in any case where these went wrong the entire batch of material was thrown away and the experiment repeated.

IV. DESCRIPTION OF EXTERNAL CHARACTERS OF NORMAL AND HYBRID LARVÆ.†

(*a*) EARLY DEVELOPMENT OF $\frac{\textit{E. ESCULENTUS}\ ♂}{\textit{E. ESCULENTUS}\ ♀}$

The four-armed pluteus stage is reached in about four to six days from date of fertilization. It then has a symmetrical body, well rounded at the posterior pole, with slender arms, longer than the depth of the body. It is slightly pigmented. A few days later (from seven to nine days) the third pair of arms (postero-dorsal) appears, and between the second and third weeks the anterior epaulettes. The pluteus has still a rounded posterior pole, but the arms are longer in proportion to the depth of the body. About this time the invagination which will form the oral disc of the future *Echinus* appears. At the end of about a fortnight the fourth pair of arms is formed, and about this time the posterior pole begins to flatten until it assumes the appearance of Figure 1. In about three weeks the posterior epaulettes are well advanced, and the pedicellariae have appeared.

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* In using the term "outside water," we mean water brought into the Laboratory in 3–4 gallon glass carboys, collected outside the Plymouth Breakwater in the tidal water of the English Channel, and therefore three or four miles from land. These flasks are always allowed to stand for four or five days in the Laboratory before being used, thus ensuring the absence of live sperm. By "Berkefeld water" we mean ordinary Laboratory tank-water, which is of considerably lower alkalinity than "outside water," which has been treated with animal charcoal, aerated and filtered through a Berkefeld filter and then stored in sterilized flasks. See Allen and Nelson (1).

† The nomenclature used in this paper is that of Mortensen (13).

It may be here stated that the times given for the appearance of different organs are only very approximate. There is the widest difference in rate of development not only between the individuals in each jar, but between the larvæ of separate cultures reared from ova and sperm of the same Echini under apparently the same conditions.

EXTERNAL CHARACTERS OF LATE LARVA (FIG. 1).

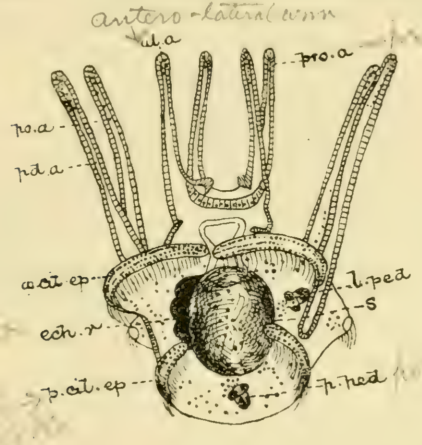

FIG. 1.—Larva of *E. esculentus* ♂ × *E. esculentus* ♀. Dorsal view. ×36. 22 days old. The specimen is tilted forward so that the posterior surface is shown. *a. cil. ep.* — Anterior ciliated epaulette. *al. a.* — Antero-lateral arm. *ech. r.*—Echinus rudiment. *l. ped.*—Lateral pedicellaria. *pro. a.*—Preoral arm. *p. cil. ep.*—Posterior ciliated epaulette. *p. ped.*—Posterior pedicellaria. *pd. a.*—Postero-dorsal arm. *po. a.*—Post-oral arm. *s.*—Stomach.

The body is rather deeper than wide, and the posterior pole somewhat flattened. It is studded with pigment spots of various shades from yellow to reddish brown, and of various shapes and sizes. In the specimen from which the drawing was made the body was regularly pigmented, while little, if any, pigment appears on the arms except at the extremities. Pigment, however, varies widely among individuals of the same culture in depth of colour and distribution, and this seems natural, since MacBride (11) has shown that the pigment is contained in wandering amoebocytes and is an excretory product in process of removal.

There are four pairs of long, slender arms, and along their edges run the ciliated bands. Around the anterior margin of the body are the "anterior ciliated epaulettes." These arise as four horizontally placed crescentic bands of cilia, constricted off from the main ciliated band, at the base of the post-oral and postero-dorsal arms. They gradually grow together, and before metamorphosis form a complete ring round the anterior pole of the body. In the figure they have not yet united dorsally. They are spotted with brown pigment, and carry powerful cilia, which in these late stages are the principal means of locomotion. At the posterior end are the "posterior ciliated epaulettes." These are pigmented and ciliated like the anterior epaulettes, and eventually will extend round the posterior pole of the larva.

There are three pedicellariae: one at the posterior pole, and two on the right side, one dorsal, and one ventral, the latter of which is not seen in the figure.

On the left hand, lying against the stomach, is the Echinus rudiment. Between this stage and metamorphosis there will not be much change in the appearance of the larva, except in the increased size of the Echinus rudiment and the union of the posterior epaulettes.

Thus the salient external features of the late larva of $\frac{\textit{E. esculentus}\ \text{♂}}{\textit{E. esculentus}\ \text{♀}}$ are:—

The anterior epaulettes.
The posterior epaulettes.
Three pedicellariae.
  One right side dorsal.
  One right side ventral.
  One at the posterior pole.

(*b*) EARLY DEVELOPMENT OF $\frac{\textit{E. MILIARIS}\ \text{♂}}{\textit{E. ESCULENTUS}\ \text{♀}}$

There was a good deal of variation among the four-armed plutei of this hybrid. The majority inclined to the pointed, clear, lightly pigmented *miliaris* type, but did not develop a preoral lobe. On the other hand, there were some that showed distinctly *esculentus* characters. In the course of development the posterior pole becomes more rounded, and, when the anterior epaulettes were formed, either the larvæ were distinctly *esculentus* in shape, or intermediate between *esculentus* and *miliaris*. The posterior epaulettes did not show much advance until the end of the fourth week, by which time the right dorsal pedicellaria was well established.

EXTERNAL CHARACTERS OF LATE LARVA (FIG. 2).

The body is not so wide as the pure *E. miliaris*, or so deep and flattened at the posterior pole as the pure *E. esculentus*. There is a good deal of brown pigment arranged in rather regular patches on the body, and also on the arms which are intermediate in form between the stumpiness of pure *miliaris*, and the length and slenderness of pure *esculentus*. The deeply pigmented anterior epaulettes have nearly surrounded the anterior margin of the body. The posterior epaulettes are not so far advanced. There are three pedicellariae, one at the posterior pole, and two on the right side, dorsal and ventral, the latter of which does not appear in the figure. On the left side is the young Echinus, well advanced, and with protruding tube-feet. The chief external features of this hybrid are:—

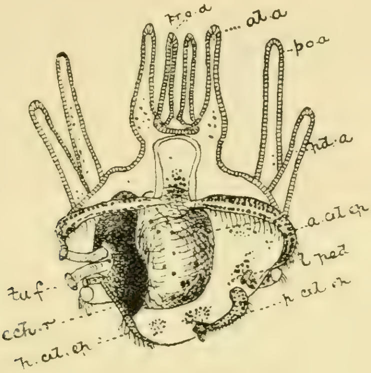

FIG. 2.—Larva of *E. miliaris* ♂ × *E. esculentus* ♀. Dorsal view. × 36. 36 days old. This larva is more advanced than that shown in Fig. 1, and the tube-feet of the the young Echinus are protruded. *tu.f.*—Tube-feet. The remainder of the lettering as in Fig. 1.

The anterior epaulettes.
The posterior epaulettes.
Three pedicellariae.
  One right side dorsal.
  One right side ventral.
  One at posterior pole.

(c) EARLY DEVELOPMENT OF $\frac{\textit{E. MILIARIS} \male}{\textit{E. MILIARIS} \female}$

The four-armed pluteus of *E. miliaris* is readily distinguished from that of *E. esculentus*. It is smaller, the posterior end is more pointed, and the arms are shorter as compared with the length of the body. It carries less pigment on the body than *esculentus;* and, in the early stages, there is often a very regular line of small pigment spots along the ciliated bands.

A marked preoral lobe overlies the mouth; and the larva generally presents a peculiar glassy, transparent appearance.

As the larva develops it retains its elongated form until about the time that the epaulettes appear. The posterior pole then gradually becomes more rounded, and finally assumes the shape depicted in Fig. 3.

The time of appearance of the other pairs of arms, epaulettes, Echinus rudiment, etc. was very variable, but on the average did not greatly differ from that of *E. esculentus.*

EXTERNAL CHARACTER OF LATE LARVA (FIG. 3).

The body is wider than deep, and the posterior pole more rounded than in *E. esculentus.*

There are comparatively few pigment spots on the body and arms, and this is generally the case with *E. miliaris.* Besides this pigment, which is of much the same colour as in *E. esculentus*, about the end of the third week, when the epaulettes are forming, a large mass of bright green pigment appears at the base of each. It always makes its first appearance at these points, but afterwards appears in spots on the arms, and just before metamorphosis is widely diffused. This green pigment is not found in *E. esculentus.* The arms are shorter and more stumpy than in those of *E. esculentus.*

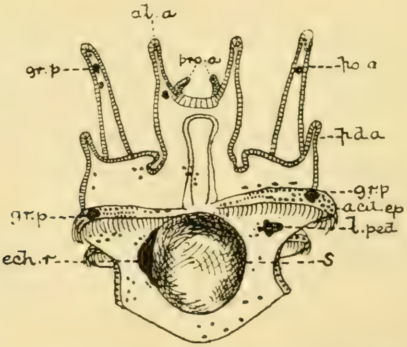

FIG. 3.—Larva of *E. miliaris* ♂ × *E. miliaris* ♀. Dorsal view. × 36. 20 days old. *gr.p.*—Green pigment. Other lettering as before.

There is only one set of epaulettes, the anterior, and they gradually close together and encircle the anterior pole of the body. They are dotted with yellowish brown pigment, generally of a lighter shade than in *E. esculentus*, and carry strong cilia.

There are two pedicellariae on the right side, one dorsal and one ventral; the latter not being shown in the figure. On the left of the stomach is the Echinus rudiment. Between this stage and metamorphosis there is not much change except in the size of the Echinus rudiment, and the amount of green pigment.

The chief external features are:—

Anterior epaulettes only.
Two pedicellariae.
  One right side dorsal.
  One right side ventral.
Masses of bright green pigment.

(*d*) EARLY DEVELOPMENT OF $\frac{\textit{E. ESCULENTUS} \, \male}{\textit{E. MILIARIS} \, \female}$

The four-armed plutei differ but little from the pure *E. miliaris* larvæ of the same stage, excepting that they carry rather more pigment. A preoral lobe is present, but is not marked as in pure *E. miliaris*. The typical elongated *E. miliaris* shape is retained until about the time when the epaulettes make their appearance, when the posterior pole gradually assumes a flatter curve as in the figure.

EXTERNAL CHARACTER OF LATE LARVA (FIG. 4).

The body is not so deep, and the arms are longer than those of the pure *E. miliaris*, but the general appearance is very similar. The whole body, and the ciliated bands, are spotted with pigment of various shades of reddish brown.

There is besides a large mass of green pigment at the bases of the epaulettes, and another mass of the same has appeared between their ends, and later on more will probably appear.

There is only one set of epaulettes, which ultimately encircle the anterior margin of the body. They are spotted with brown pigment and carry strong cilia.

There are two pedicellariae, one dorsal and one ventral, on the right side (the latter not shown in Fig. 4).

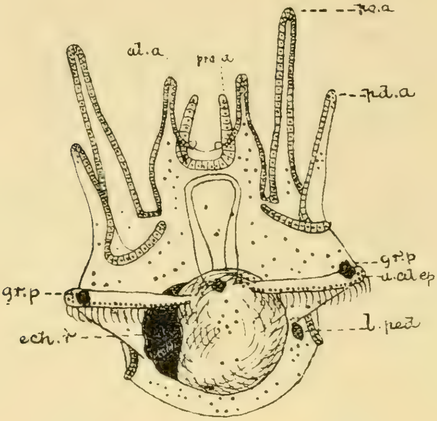

Fig. 4—Larva of *E. esculentus* ♂ × *E. miliaris* ♀. Dorsal view. ×36. Forty days old. Although it is twice the age of that shown in Fig. 3, there is little difference between them, except in size. Lettering as before.

This pluteus is twenty days older than the pure *E. miliaris* (Fig. 3), but beyond an increase in size there is little difference.

The chief external features of this hybrid are :—

The anterior ciliated epaulettes.
Two pedicellariae.
  One right side dorsal.
  One right side ventral.
Masses of green pigment.

(*c*) EXTERNAL CHARACTERS OF THE LATE LARVÆ $\frac{\textit{E. ACUTUS}\ ♂}{\textit{E. ACUTUS}\ ♀}$

Regarding *E. acutus* and *E. esculentus* as distinct species, it might be expected that their late larvæ would show some marked specific differences. Such differences we have, however, been so far unable to discover. The late larva of *E. acutus* resembles that of *E. esculentus* in number and position of pedicellariae, of ciliated epaulettes and in the absence of green pigment. Superficially the larva of *E. acutus* has a smaller body and slenderer arms, with darker and more abundant pigment than that of *E. esculentus*, but hybrids between these species afford no criteria by which parental influence can be discriminated.

Hybrids, however, between *E. acutus* ♂ and *E. miliaris* ♀ resemble those between *E. esculentus* ♂ and *E. miliaris* ♀, in the absence of the posterior pedicellaria and of the posterior ciliated epaulettes and the possession of green pigment masses, while in the reciprocal cross the characters common to *E. acutus* and *E. esculentus* make their appearance.

SUMMARY OF LATE LARVAL CHARAC

	Anterior epaulettes.	Posterior epaulettes.	Green pigment.	Right dorsal pedicellaria.	Right ventral pedicellaria.	Posterior pedicellaria.
E. esculentus ♂ *E. esculentus* ♀	+	+	○	+	+	+
E. miliaris ♂ *E. esculentus* ♀	+	+	○	+	+	+
E. miliaris ♂ *E. miliaris* ♀	+	○	+	+	+	○
E. esculentus ♂ *E. miliaris* ♀	+	○	+	+	+	○

Considering only these six external characters the experiments of 1910–11 show that:—

1. The egg of *Echinus esculentus* fertilized by its own sperm produces a late larva having anterior epaulettes, posterior epaulettes, no green pigment, one right side dorsal pedicellaria, one right side ventral pedicellaria, one posterior pedicellaria.

2. The egg of *Echinus esculentus* fertilized by sperm of *Echinus miliaris* produces a late larva having anterior epaulettes, posterior epaulettes, no green pigment, one right side dorsal pedicellaria, one right side ventral pedicellaria, one posterior pedicellaria.

These characters are the same as 1.

3. The egg of *Echinus miliaris* fertilized by its own sperm produces a late larva having anterior epaulettes, no posterior epaulettes, green pigment, one right side dorsal pedicellaria, one right side ventral pedicellaria, no posterior pedicellaria.

4. The egg of *Echinus miliaris* fertilized by sperm of *Echinus esculentus* produces a late larva having anterior epaulettes, no posterior

epaulettes, green pigment, one right side dorsal pedicellaria, one right side ventral pedicellaria, no posterior pedicellaria.

These characters are the same as 3.

V. CHARACTERS OF THE SKELETON.

While we have already stated that the skeleton is extremely variable, and is a doubtful index of parental influence, what evidence we have been able to derive from the study of a large number of larvæ seems distinctly to bear out some of the more recent contentions. While we reserve the publication of a large number of figures of the skeletal apical rods, we have inserted one typical example of each cross (Fig. 5). Here the evidence would seem to be distinctly in favour of the dominance of one character over another, as brought out by Loeb, King, and Moore (10). For, with reference to Fig. 5, it will be seen that the normal apical skeleton of *E. esculentus* is slender, arched, and somewhat spinous, that of *E. acutus* is more robust and bears a greater number of spinous processes, while that of *E. miliaris* is straight and club-shaped, bearing a few blunt knobs.

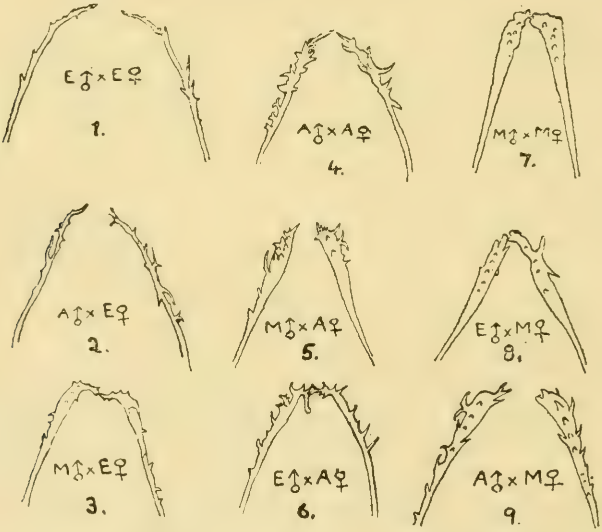

Fig. 5.—Skeletal apical rods of four-armed Plutei. 1. *E. esculentus* ♂ × *E. esculentus* ♀. 2. *E. acutus* ♂ × *E. esculentus* ♀. 3. *E. miliaris* ♂ × *E. esculentus* ♀. 4. *E. acutus* ♂ × *E. acutus* ♀. 5. *E. miliaris* ♂ × *E. acutus* ♀. 6. *E. esculentus* ♂ × *E. acutus* ♀. 7. *E. miliaris* ♂ × *E. miliaris* ♀. 8. *E. esculentus* ♂ × *E. miliaris* ♀. 9. *E. acutus* ♂ × *E. miliaris* ♀.

Loeb states that the spinous condition, as is exhibited for example by *E. esculentus* and *E. acutus* (Fig. 5), is dominant over the smooth, as seen in *E. miliaris*; and that the clubbed condition, like that of *E. miliaris*, is dominant over the arched form, as that of *E. esculentus*. This inheritance is stated to take place irrespective of whether the characters are paternal or maternal. This we find to be the case in our crosses, but we also find that the female has a stronger influence on the character of the hybrid skeleton than the male. As an illustration of the dominance of the spinous condition over the smooth, it will be seen in Fig. 5 that in the cross *E. acutus* ♂ × *E. miliaris* ♀ and its reciprocal the rough condition appears. Again, with regard to the clubbed and arched conditions, in the cross *E. esculentus* ♂ × *E. miliaris* ♀ and its reverse the clubbed form appears in the hybrids. It is also clear from the figure that maternal influence is stronger than the paternal.

VI. THE CHEMICAL CONTROL OF INHERITANCE.

In 1910 Tennent (18), working at Tortugas, made the cross *Toxopneustes* ♂ × *Hipponöe* ♀ and its reciprocal, producing hybrid larvæ which had, in both cases, the characteristics of *Hipponöe*. The skeleton was used as an index of parental influence, and we have already discussed the doubtful value of this evidence. He altered the concentration of the OH–ions in the water in which the fertilizations were made, by adding small definite quantities of Sodium hydrate and of Acetic and Hydrochloric Acid. By this means he claims to have altered the dominance, so that the hybrid skeleton now resembled that of *Toxopneustes*. While, from a close examination of his figures, it is clear that a considerable percentage of his Plutei showed skeletal abnormalities, his main result may or may not be considered as proved. If it is true, the conclusion is obviously a very important one, and one which should be tested with other material and at other places. For this reason, although the inheritance of the late larval characters of the hybrids at Plymouth is strictly maternal, and is not determined by any particular species, yet these characters are of such a definite nature, that we thought it to be a good opportunity for repeating this work.

With this object the crosses *E. esculentus* ♂ × *E. miliaris* ♀ and *E. acutus* ♂ × *E. miliaris* ♀, and their reciprocals were made. The eggs were placed in sea-water, the OH–ion concentration of which had been altered by the addition of .25 to 1 cc. N/10 NaOH in the one case, and HCl or Acetic Acid, in the other, per 200 cc. of sea-water. As soon as the blastulae swam to the surface, they were transferred to "outside" or to "Berkefeld sea-water." At the same time, cultures of the same crosses were made, which were fertilized and raised from the commencement in sea-water of the normal OH–ion concentration.

A large number of larval skeletons were examined at about ten days old, drawings of which will appear in the forthcoming work, but in no case was the inheritance at all affected. At a late stage (30–40 days), again, a large number of Plutei were examined, but in no case could any alteration in the inheritance of the posterior ciliated epaulettes, the pedicellariae or the green pigment masses, be detected. Figs. 6 and 7 show typical 28-day Plutei of the cross *E. acutus* ♂ × *E.*

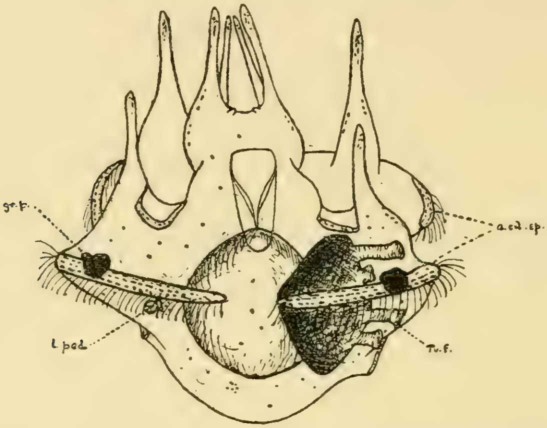

FIG. 6.—Larva of *E. acutus* ♂ × *E. miliaris* ♀. Dorsal view. 28 days old. Fertilized in water with raised OH–ion concentration. *a. cil. ep.*—Anterior ciliated epaulette. *gr. p.*—Green pigment. *l. ped.*—Lateral pedicellaria. *tu. f.*—Tube-foot.

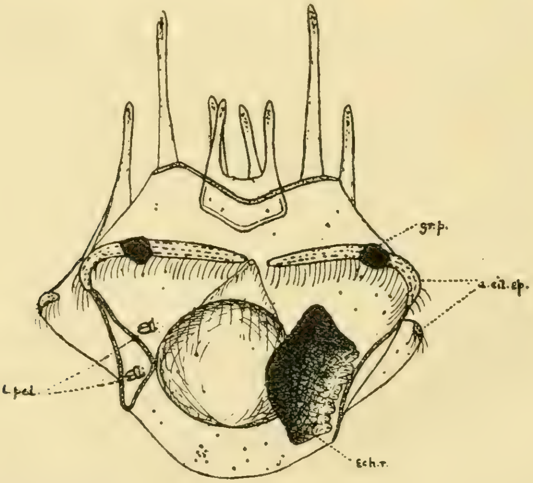

FIG. 7.—Larva of *E. acutus* ♂ × E. *miliaris* ♀. Ventral view. 28 days old. Fertilized in water with lowered OH–ion concentration. *a. cil. ep.*—Anterior ciliated epaulette. *ech. r.*—Echinus rudiment. *gr. p.*—Green pigment mass. *l. ped.* Lateral pedicellaria.

miliaris ♀ which had been fertilized in water treated respectively with alkali and acid. It will be seen that they differ in no essentials from the hybrids raised in normal sea-water. The inheritance of the maternal pigment masses, absence of posterior ciliated epaulettes and absence of posterior pedicellaria is unchanged.

VII. THE CHARACTERS OF THE YOUNG SEA-URCHIN.

In all cases the young fully formed Urchins, in superficial features, such as the character of the spines, pigmentation, etc., show a motherly influence, but so far we have not made a close examination of the number and structure of the test plates. The young Urchins always secrete a thick layer of mucus on the surface of the test, which effectually prevents any examination of the plates in the living state, and any such examination necessitates killing the hybrids. We wish to reserve for a future occasion our statements on this head.

There is this important feature about the tube feet of *E. miliaris*, to which attention has been drawn by MacBride (11). He has shown that the young *E. esculentus* and *E. acutus* walk by means of five tube feet, each forming the termination of one of the radial canals, and each provided with a sucker, in the centre of the disk of which is a sense organ consisting of elongated cells. In each radius there are in addition the rudiments of a pair of tube feet, which are mere buds in these species, but in *E. miliaris* these accessory tube feet are functional at metamorphosis. So we have this important distinction between the normal just metamorphosed *E. miliaris* and *E. esculentus* or *E. acutus*, that the former has five principal tube feet and ten secondary ones, while the two latter have only the five principal ones, the secondary ones being entirely rudimentary at this stage. This, therefore, offers a definite index of parental influence after metamorphosis. On this head also we wish to defer our statements, to incorporate them later with the evidence offered by the study of the structure and number of the hybrid test plates.

VIII. SUMMARY OF CONCLUSIONS.

1. As the result of extensive investigation of the early larval history of our various crosses, we have come to the conclusion that these are too variable to afford any definite evidence of parental influence, and especially is this true with regard to the skeleton, heretofore considered the chief index of inheritance.

2. What little evidence we have been able to derive from the study of a very large number of skeletons of both normal and hybrid crosses, seems to show that, while the paramount influence is always maternal,

there is considerable evidence for the contention put forward by Loeb, King, and Moore (10) that the minor skeletal characters are inherited independently of either parent. We are able to bear out their statement that with regard to the apical rods, the spinous condition of which is dominant over the smooth, and the clubbed condition over the arched, quite independently of their origin either from the paternal or the maternal side.

3. Regarding the early larval characters, therefore, as of too variable a nature, we have reared the normal and hybrid crosses to the young Urchin stage, in the hope of finding, in the late development, more definite characters for the solution of the question of inheritance. In the presence or absence of the posterior ciliated epaulettes, of the green pigment masses and of the posterior pedicellaria, we claim that we have found such definite characters, and we find them to be invariably inherited through the egg. A full summary of these facts has already been given in § IV, page 135.

4. We have shown that an alteration of the alkalinity of the water affects the inheritance neither of the skeletal characters nor of those of the late larva.

5. The young hybrid Urchins, some of which have already reached a considerable size and are now two years old, are, in superficial appearance, of the pure motherly type.

6. We suspect that a considerable amount of hybridization occurs under natural conditions between *E. esculentus* and *E. acutus.*

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The Action of some Denitrifying Bacteria in Tropical and Temperate Seas, and the Bacterial Precipitation of Calcium Carbonate in the Sea.

By

G. Harold Drew.

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INTRODUCTION.

It is generally conceded that the plankton of tropical and sub-tropical seas is far less in quantity than that found in colder waters.

The zoö-plankton depends ultimately for its food on the phyto-plankton; hence any factor limiting the growth of the phyto-plankton, which is capable of functioning in tropical and not in temperate or Arctic waters, might offer an explanation of this phenomenon. It has been shown by various investigators that this factor is not temperature, light, or salinity, and it has been suggested that the explanation may lie in the relative deficiency in tropical seas of the nitrates or nitrogenous compounds which are so essential for all plant life. A matter of common observation in support of this view is the remarkable scarcity of algal growth in the shallow waters of tropical shores as compared with that in similar situations in temperate regions, and the fact that in the tropics, wherever sewage or other nitrogenous waste is poured into the sea, a free growth of algæ is found.

At present no reliable and accurate chemical method of estimating the combined nitrogen in sea-water exists, hence this theory cannot be directly put to the test. On the other hand, the existence of denitrifying bacteria in temperate waters has long been known, and it would seem a fair deduction that should this bacterial destruction of nitrates take place with greater intensity and completeness in tropical than temperate waters, an explanation of the relative scarcity of plankton in the former would be offered, and it was with the object of investigating this question that the present work was undertaken.

My thanks are due to the Marine Biological Department of the Carnegie Institute of Washington, U.S.A., for their kindness in accommodating me in their Laboratory at Loggerhead Key, Dry Tortugas, and at their temporary Laboratory in Port Royal, Jamaica, B.W.I., and also to the Marine Biological Association of the United Kingdom for giving me facilities for work in their Plymouth Laboratory.

METHODS.

At the Dry Tortugas Laboratory, the motor-yacht *Anton Dohrn* enabled me to obtain samples of water from the middle of the Gulf Stream, and a number of smaller motor-boats were always available for shorter journeys. At Port Royal, Jamaica, it was necessary to depend on a sailing-boat, but owing to the remarkable regularity with which a breeze springs up every morning, no difficulty was encountered from this cause. At Plymouth the s.s. *Oithona* enabled me to obtain samples of water from a point seventy miles west of Ushant.

The observations were made at Port Royal during May, at the Tortugas during June, and at Plymouth in August, 1911.

For purposes of comparison an endeavour was made in every case to obtain samples of water from localities where truly oceanic conditions prevailed, and hence samples were not obtained from the English Channel, where previous experience had shown that the bacterial flora was abundant and varied, owing to contamination from the land.

Surface samples were collected in sterilized wide-mouthed stoppered bottles holding about twelve ounces. Care was taken to avoid contamination from the sides of the boat by always collecting the samples from the bows when the boat was going ahead.

Deep samples were collected at the Tortugas in retort-shaped glass flasks of about 300 c.c. capacity, with narrow, recurved, long-drawn-out necks. These were sterilized, exhausted, and sealed: they were then lowered in an apparatus in which the extremity of the neck could be broken off at any desired depth by sending a messenger down the sounding wire, when the flasks became completely filled with water. After hauling up, a little water was shaken from the neck, and it was then sealed with the blow-pipe. By this method risk of contamination from more superficial layers of water as the apparatus is drawn up is avoided, since the changes in pressure and temperature as it ascends tend to cause a continuous outflow through the narrow neck until the surface is reached. The samples were taken back to the Laboratory, and cultures were made within three hours of collecting.

A somewhat similar apparatus was used for obtaining deep samples from the station seventy miles west of Ushant, but the glass bulbs were smaller and the tube leading from them was bent at right angles to itself. Considerable difficulty was caused by the breaking of the tube, owing to the force of the inrushing stream of water impinging on the wall where it was bent at right angles. After collecting the sample, the tubes were sealed with melted paraffin wax, and this method does not appear to have caused any bacterial contamination of the samples. Attempts to make Agar plate cultures in Petri dishes on board did not give satisfactory results, as, owing to the motion of the boat, the jelly set in irregular waves and lumps. Consequently the samples were kept in ice, and cultures were made from them at Plymouth twenty-four hours after collection. It is clear that if in the future attempts are made to make plate cultures on board a small boat, a very delicately swung table will be necessary, or else the roll tube culture method must be employed.

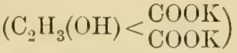
In Jamaica no apparatus for obtaining deep samples was available, so the primitive method of lowering a sterilized stoppered bottle with a string tied to the stopper was employed. At the required depth the stopper was pulled out until the bottle was nearly full, and then allowed to fall back in place. This method can only be used for very slight depths, owing to the pressure of the water at greater depths making it impossible to withdraw the stopper: a source of error also is introduced in that the inrushing water passes in close proximity to the stopper and its attachments, and may carry in bacteria which have adhered to them when passing through the surface layers.

The media most commonly employed for isolating the bacteria in plate cultures had the following composition:—

I. Peptone Agar.

Peptone	2·0 grammes.
Potassium nitrate (KNO_3) . . .	0·5 ,,
Sea-water	1000·0 c.c.
Agar Agar.	12·0 grammes

II. Potassium Malate Agar.

Potassium malate  $\left(C_2H_3(OH)<\begin{matrix}COOK\\COOK\end{matrix}\right)$	1·0 grammes.
Sodium phosphate ($Na_2HPO_4,12H_2O$)	0·25 ,,
Potassium nitrate (KNO_3)	0·5 ,,
Sea-water	1000·0 c.c.
Agar Agar	12·0 grammes.

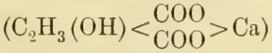
The medium was only filtered through glass wool, so that a very slight floccular precipitate of Calcium phosphate was retained.

For other purposes a simple solution of Peptone in sea-water was employed (2 grammes to 1000 c.c.), and media were also used consisting of this Peptone solution with the addition of 0·5 per cent of various carbohydrates, such as Cane-sugar, Dextrose, Laevulose, Mannite, Lactose, etc., with sufficient Neutral Red solution to colour them.

In the case of Gelatin media, it was necessary to keep them artificially cooled to a temperature of between 20° and 25° C., as in the Tortugas the Laboratory temperature occasionally rose as high as 37° C., at which temperature Gelatin media will not remain solid.

When comparing various samples of water as to their power of causing denitrification in culture media, the following uniform method was employed:—

> 10 c.c. of each sample was added to 1000 c.c. of a modification of of Gran's medium (see *Studien über Meeresbacterien*, by H. H. Gran, Bergens Museums Aarbog, No. 3, 1901). This culture fluid was sterilized in glass flasks and has the following composition:—

Potassium nitrate (KNO_3)	0·5 grammes.
Sodium phosphate (Na_2HPO_4, $12H_2O$)	0·25 grammes.
Calcium malate  $\left(C_2H_3\,(OH)<\begin{matrix}COO\\COO\end{matrix}>Ca\right)$	about 5·0 grammes.
Sea-water	1000·0 c.c.

> Calcium malate is only slightly soluble in water (about $\frac{1}{20}$th per cent), and so can be added in excess.

The reduction of the nitrate to a nitrite was tested for by the addition of 5 c.c. of 10 per cent Sulphuric acid and 2 c.c. of a 1 per cent solution of Metaphenylene diamine hydrochloride to 25 c.c. of the culture. The production of a brown coloration (due to the formation of Bismark brown) is an indication of the presence of a nitrite, and is an extremely delicate reaction.

The formation of Ammonia was tested for by the addition of 5 c.c. of a 10 per cent solution of Potassium hydrate, and 5 c.c. of Nessler's reagent: the white precipitate formed on the addition of the Potassium hydrate does not appreciably interfere with the test, though it renders it somewhat less delicate.

The presence of nitrates or nitrites remaining in the culture fluid after the bacterial action was tested by the extremely delicate Brucine and Diphenylamine reactions.

THE INVESTIGATION OF SAMPLES OF WATER TAKEN OFF PORT ROYAL, JAMAICA.

In Jamaica, a measurement of the rate of denitrification in the modified Gran's medium inoculated with samples of sea-water was made, but the isolation of the bacteria on solid media was not attempted, owing to lack of apparatus.

Samples of sea-water were collected in sterilized stoppered bottles from the surface, and from depths of three and six fathoms, in positions about five miles from shore, where, from a consideration of the wind and tide, the water was probably under truly oceanic conditions, and unaffected by the neighbouring land.

The cultures were kept in a moderately dim light, and the room temperature ranged between 25° and 31·5° C. The average temperature during the growth of each culture was noted.

In a typical culture made from surface water, and for which the average temperature was 29° C., the first indication of the formation of a nitrite, as given by the Metaphenylene diamine reaction, appeared after twenty-seven hours: after thirty-eight hours the brown colour produced in this reaction was very intense, the culture became cloudy, and on testing with Nessler's reagent, slight Ammonia formation was apparent. After forty-eight hours the culture became very cloudy and a scum of bacterial growth developed: the nitrite and Ammonia reactions remained unaltered. After sixty-three hours the nitrite reaction was somewhat less marked, the Ammonia reaction was unaltered, and bubbles of gas began to appear. After seventy-two hours many bubbles of gas were being produced and the nitrite and Ammonia reactions were very slight. After eighty-six hours the bubbling had ceased, and no nitrite or Ammonia was present in the cultures. Testing the culture for nitrates by the Diphenylamine and Brucine methods, showed that no nitrates or nitrites were left in the solution. In the absence of a gas analysis apparatus the nature of the gas evolved could not be exactly determined, but considering that it was non-inflammable, did not turn lime-water milky, and that the nitrate originally present had been destroyed, it seems strongly probable that this gas was pure Nitrogen.

Thus at a temperature of 29° C., 0·5 grammes of Potassium nitrate were decomposed in eighty-six hours, and it was found that if a further 0·5 grammes of Potassium nitrate was added to the culture, it was in turn rapidly decomposed: this could be repeated indefinitely until the other constituents of the medium were used up, or the concentration of waste products became too high.

The rate of denitrification varied considerably with the temperature, and in cultures kept at a temperature between 10° and 12°C., no growth or denitrification occurred. Denitrification was more rapid in cultures from water taken from a depth of three or six fathoms than from the surface. It was also especially rapid with samples taken from the thick, muddy waters of a mangrove swamp, where organic matter was plentiful.

The bacteria present in the cultures were very minute, actively motile bacilli with rounded ends.

THE INVESTIGATION OF SAMPLES OF WATER TAKEN ROUND THE DRY TORTUGAS AND IN THE STRAITS OF FLORIDA.

Cultures made in the modified Gran's medium from various positions round the Tortugas gave results in close accord with those found in Jamaica, and the average rate of denitrification was the same; hence it appears probable that much the same bacterial conditions obtain in both places. Cultures were made on various solid media, and pure cultures of the bacteria were isolated. Petri dishes with porous earthenware covers were used and were found of great advantage, as by this means the formation of drops of water on the covers is prevented, and the water of condensation evaporates as soon as formed: in addition a free air supply is ensured. If evaporation is progressing too rapidly, the whole Petri dish can be covered with a bell-jar lined with damp filter-paper after the first day.

By plating samples of surface water from various positions as far as possible removed from the influence of the land, an average of fourteen colonies per 1 c.c. sea-water was obtained. These colonies appeared to be of two kinds, one much more plentiful than the other. Subcultures made from these colonies in Gran's medium showed that the bacteria forming the most common type of colony produced an active denitrification, while the others grew very slowly in this medium, and produced no denitrification. The chief characteristics of the denitrifying form are as follows:—

On the Potassium malate, or Peptone Agar media, colonies are visible as minute white specks after six to eight hours, when the room temperature averages 29·5° C. After about eighteen hours the colonies are well developed, they are white in colour, circular, but with finely irregular outline, and have a granular appearance. Superficial colonies are much elevated at first, but as growth proceeds, spread rapidly over the surface of the Agar. The deep colonies remain small, circular, and discrete. Growth is somewhat more rapid on the Peptone Agar than on the Potassium malate Agar, and the older colonies develop a brownish tinge in the centre when growing on the former medium.

On Gelatin Peptone (5 per cent Peptone, kept at between 20° and 25° C. to ensure the medium remaining solid) growth was very slow; in stab cultures growth proceeded slowly from the surface downwards, forming a funnel-shaped depression of liquefied gelatin. Acid formation occurs in Glucose, Mannite, and Cane-sugar, but not in Lactose media.

Growth is totally inhibited at a temperature of 10° C., but takes place slowly at 15° C.

Growth is much retarded by exposure to bright sunlight, but the bacteria are not killed by a ten hours' exposure.

The bacteria are facultative anaërobes, but growth under anaërobic conditions is very slow.

In Gran's medium growth and denitrification are rapid, but no growth occurs if the Potassium nitrate be omitted, or if the Calcium malate be replaced by Calcium carbonate. Growth in a pure solution of Peptone in sea-water is very slight, but becomes abundant if Potassium nitrate be added, when denitrification quickly ensues.

In its cultural reactions this bacterium is very similar to certain denitrifying forms found in the English Channel. The chief points of difference consist in its much greater denitrifying power, and the higher temperature necessary for its growth, by which it would be prevented from spreading into colder waters.

The characteristics of the scarcer, non-denitrifying, form of bacterium found on the Peptone Agar plates made from surface samples are as follows:—

Growth on the Potassium malate Agar medium is very slow and indefinite. On Peptone Agar growth is somewhat slower than in the case of the denitrifying form. On the surface, circular cream-coloured colonies are formed having a brownish centre, the edges are smooth and regular, and the colony remains discrete and does not tend to spread over the surface. The deep colonies are smaller and usually ovoid in shape, and of a somewhat darker colour than those on the surface. Growth does not occur on gelatin media.

Acid formation takes place in Glucose, but not in Cane-sugar, Lactose, or Mannite media.

Growth is much retarded by exposure to a strong light, and cultures on sloped Peptone Agar are completely killed by four hours' exposure to bright sunlight.

The bacterium is a strict aërobe.

Free growth takes place in Gran's medium, but develops much slower than in the case of the denitrifying form: no growth occurs if the Potassium nitrate be omitted entirely, but takes place freely if a mere trace in excess of that normally present in the sea-water be added, though no denitrification results. Attempts were made to discover whether this bacterium had any nitrifying or denitrifying action in various culture media, but uniformly negative results were obtained. Nitrites were neither oxidized to nitrates, nor reduced to Ammonia or free Nitrogen, and Ammonium salts were unaffected. No growth was obtained in any culture medium that did not contain at least a trace of nitrates, so it was not practicable to ascertain whether the bacterium had a nitrifying action without the necessary facilities for quantitative work.

On one occasion samples were obtained from various depths up to 90 fathoms at a point in the Gulf Stream, 25 miles south of the Dry Tortugas.

The samples were plated in the Peptone Agar medium, and counted with the following average results:—

Depth fathoms.	Denitrifying forms.	Non-denitrifying forms.	Number of colonies developing from 1 c.c. of sample.
0	9	2	11
10	25	4	29
40	2	2	4
60	5	3	8
90	5	6	11

If any deductions can be made from one series of observations, it would seem probable that the non-denitrifying bacteria are a deep-water form, and this would be upheld by the ease with which they are killed by exposure to sunlight. On the other hand, the denitrifying bacteria would appear to be a surface form, reaching their maximum a little below the surface. This would be substantiated by the results obtained in Jamaica, by which it was shown that denitrification occurred much more rapidly in cultures made from samples collected at depths of 3 and 6 fathoms, and might possibly be explained by the fact that the growth of the bacteria is inhibited by strong light.

INVESTIGATION OF SAMPLES FROM A POINT 70 MILES WEST OF USHANT.

The samples were plated in the Peptone Agar medium after having been kept on ice for twenty-four hours, for the reason previously explained.

The colonies were well developed after forty-eight hours, and appeared to be all of one kind. A count gave the following average results :—

Depth in fathoms.	Number of colonies developing from 1 c.c. of sample.
0	7
10	9
20	6
30	5
50	6
70	30
80	20

The increase in the number of colonies at 70 and 80 fathoms is somewhat remarkable, but no conclusions in this respect can be drawn from one series of observations.

The appearance and cultural characteristics of the bacterium obtained from these samples were identical with those of the denitrifying form investigated at the Tortugas, with the exception that acid formation did not take place in media containing Cane-sugar.

1000 c.c. of the modified Gran's medium inoculated on board with 10 c.c. of a surface sample immediately after collection, and kept at an average temperature of 20° C., showed the first trace of nitrite formation after 70 hours. After 84 hours a very strong nitrite reaction was obtained, and a slight Ammonia reaction was given with Nessler's reagent. The process of denitrification, even after the lapse of weeks, did not extend beyond this, and no bubbles of gas were formed. Other experiments made with subcultures from Agar and Gelatin media gave similar results, so that it appears that this bacterium cannot entirely break down nitrates at a temperature of 20° C. The optimum temperature for denitrification produced by this bacterium appears to be about 20° C., as the process was less rapid at average temperatures of 17° C. and 25° C. At a temperature of 32° C. rapid growth took place, but no denitrification resulted.

It should be noted that these temperature observations were only made with subcultures from colonies on Peptone Agar and Peptone Gelatin media, and there is reason to believe that the power of denitrification becomes diminished after cultivation on such media. Further and more accurate temperature experiments are required, in which the culture medium is directly inoculated with freshly collected samples of water.

INVESTIGATION OF SAMPLES OF WATER FROM THE MARQUESAS KEYS, AND THE EXPERIMENTAL PRECIPITATION OF CALCIUM CARBONATE BY BACTERIAL AGENCY.

The Marquesas Keys constitute a coral atoll which forms part of the long chain of Keys separating the Gulf of Mexico from the Straits of Florida. Within the atoll the water is very shallow, and the bottom consists of a fine chalky mud many feet deep. Samples of the water from within the atoll were sent to me at Plymouth by post, and examined fourteen days after collection.

On plating on Peptone Agar, 800 colonies per 1 c.c. of the sample were obtained. These colonies appeared to be all of one species, and in appearance and all cultural characteristics were identical with the denitrifying form previously described as occurring around the Tortugas.

A suspension of these bacteria from a culture on Peptone Agar was made in sterile sea-water, and a similar suspension, containing roughly the same number of bacteria, was made from a third subculture on Peptone Agar of the bacteria obtained from the station seventy miles west of Ushant. 1 c.c. of each of these suspensions was then added to 1000 c.c. of the modified Gran's medium; some of these cultures were kept at an average temperature of 20°C. and others at 32°C., with the following results:—

At 20° C. cultures from Marquesas showed trace of nitrite after 45 hours.
„ „ „ gave strong nitrite reaction „ 53 „
„ „ 70 miles W. Ushant showed trace of nitrite . . . . . „ 140 „
„ „ 70 miles west of Ushant showed strong nitrite reaction . . . „ 162 „

In both cases a slight amount of Ammonia was recognizable by Nessler's reagent when the nitrite reaction was strong, but decomposition of the nitrite did not proceed further even after fourteen days.

At 32° C. cultures from the Marquesas showed trace of nitrite after 18 hours.
,, ,, ,, gave strong nitrite reaction ,, 22 ,,
,, ,, 70 miles west of Ushant never gave
nitrite or Ammonia reactions.

The cultures from the Marquesas showed a slight amount of Ammonia formation, but the decomposition of the nitrite did not proceed further.

From these experiments it appears that the bacteria from subcultures from the Marquesas have a much greater denitrifying power than those from subcultures from a point seventy miles west of Ushant, and that as the bacteria from the Marquesas appear to be of the same species as those investigated at the Dry Tortugas, their power of causing complete denitrification in the modified Gran's medium has been lost by cultivation on Peptone Agar, or during the fourteen days journey from the Marquesas.

The presence of the thick layers of fine chalky mud within the Marquesas Keys, and elsewhere in many places near the Florida coast, led to a consideration of the possibility of its precipitation by bacterial agency.

Since these bacteria grow freely in Gran's medium, the Calcium salt of a simple organic acid is a sufficient source of organic food for them, and it seems probable that they would thrive in sea-water containing the products of decomposing vegetable matter, provided that the nitrate supply and conditions of light and temperature were suitable. Such conditions should be especially well fulfilled by the drainage into the sea of a well-wooded country with a calcareous subsoil, and the soluble organic Calcium salts carried to the sea in this way, would there be precipitated as Calcium carbonate by the action of the bacteria. In addition, the elimination of the acid radicle from the nitrate in the process of denitrification, by whatever stages it may occur, must leave the alkaline base free to destroy the normal equilibrium of the salts in sea-water, and by increasing the alkalinity, would also result in the precipitation of Calcium carbonate.

To test this theory, cultures were made in a medium having the following composition:—

Calcium succinate	2·5 grammes.
Potassium nitrate	0·5 ,,
Sea-water	1000·0 c.c.

Calcium succinate is soluble in these proportions, and the medium is quite clear. Free growth was manifested by the cloudiness of the medium forty-eight hours after inoculation, and nitrite formation was apparent. After ninety-six hours the medium appeared quite milky, and this milkiness was due to the presence of exceedingly fine particles of a substance which was soluble in dilute hydrochloric acid with evolution of gas, and was presumably Calcium carbonate. These particles were so minute that they remained in suspension in the liquid, and could only be satisfactorily separated from it by centrefugalizing. The addition to this culture of very fine particles of hydrated Calcium sulphate, or of larger particles of sand, resulted in the aggregation around them of the particles of Calcium carbonate, forming a concentrically laminated concretion around a central nucleus. These concretions were hard, and of almost crystalline appearance under the microscope, and were soluble in dilute Hydrochloric acid with evolution of bubbles of a gas which when the operation was performed on a microscopic slide, could be completely absorbed by running in a solution of Sodium hydrate under the cover slip. Once this process of concretion has been initiated, it appears to progress independently of the presence of particles which act as nuclei, and a large concretion may often be found having a number of smaller concretions around it, or continued into a chain of small spheres, the whole presenting somewhat the arrangement shown by freely budding yeast cells. The deposition of this form of Calcium carbonate also takes place on the sides of the flask, and more especially over any area where the glass is scratched or roughened.

It would seem a reasonable suggestion that similar bacterial agency may have played a part in the formation of oölitic limestones, which are composed of concretions of Calcium carbonate around central nuclei often consisting of particles of sand or shells. In the same way bacterial action may have been of great importance in the precipitation of the various chalk strata, and indeed in the formation of many rocks largely composed of Calcium carbonate.

If this view as to chalk and oölitic limestone formation is correct, it would seem probable that the precipitation of these rocks must have occurred in comparatively shallow seas, which received the drainage from a country in which extensive weathering of rocks containing Calcium salts was progressing, and where there was a considerable amount of vegetation from the decay of which the organic matter necessary for bacterial growth would be derived.

DISCUSSION OF RESULTS.

It seems that the rate of denitrification in equal volumes of the same culture medium, inoculated with equal volumes of samples of sea-water, must be a function of the number of bacteria in the sample, the temperature at which the cultures are grown, and the specific power of denitrification of the individual species of bacteria. Considering the rapid multiplication of bacteria when the food supply is plentiful, up to a maximum determined chiefly by the accumulation of the waste products of their own metabolism, it appears that the factor of the number of bacteria in the sample may be neglected within the limits of these experiments. For example, the number of bacteria in 1000 c.c. of Gran's medium at the end of twenty-four hours would probably be much the same, whether it were inoculated from a sample containing eight or sixteen bacteria per 1 c.c. Similarly, it was a matter of experience that the first trace of nitrite formation was observable at about the same time, whether 5 or 10 c.c. of a given sample had been used for inoculation.

Consequently it appears that, for purposes of comparison, and within the limits of the experiments described, if the temperature be the same for the cultures compared, the rate of denitrification is a measure of the specific denitrifying power of the particular species of bacteria.

Thus it has been shown that in cultures grown at temperatures approximating that of their normal environment, the denitrifying power of bacteria in seas in the American tropics is considerably greater than that of bacteria in the water to the north of the Bay of Biscay, and that they have the power under favourable conditions of completely breaking down nitrates, which those from the Bay of Biscay do not possess.

It has also been shown that these bacteria possess the power of precipitating Calcium carbonate from solutions of simple organic Calcium salts, and it is here suggested that some similar action has played an important part in geologic times in the precipitation of various rocks, wholly or in part composed of Calcium carbonate.

Investigation and comparisons of denitrifying power of samples of the coastal waters of the English Channel have been purposely avoided, as previous experience had shown that the bacterial conditions in this region are so very complicated. It should, however, be mentioned that in this coastal water denitrifying bacteria are present which are capable of entirely decomposing nitrates into free Nitrogen, e.g. the *Bacillus repens* (Gran), but that this complete denitrification is only possible at a temperature far higher than that of their normal environment, and that at a temperature of 15° C. even the formation of nitrite from the nitrate takes place with considerable slowness.

A point that has not yet been considered is the origin of the nitrate supply in the sea. Nitrates are absorbed by diatoms and the phytoplankton in general, and are presumably built up into complex nitrogenous compounds within the plant. If these compounds, on the death of the plant, are broken up and the Nitrogen again rendered available for use in the form of nitrates, a series of reactions must be gone through which may well be performed by bacterial agency, and this also applies to the waste nitrogenous products of animal metabolism. In addition, it has been shown that nitrates are actually destroyed by the denitrifying bacteria, which would thus tend to keep the nitrate concentration down to the level necessary for their own existence, and would come into competition for this essential with other forms of plant life. If the bacteria are successful in decomposing nitrates to the extent of entirely removing the Nitrogen from all chemical combination, as seems probable from the experiments in cultures, it follows that there must be some source of nitrates in order that the concentration in the sea may remain constant. The existence of nitrifying bacteria, which are capable of oxydizing the Nitrogen of the air to form nitrates, and are symbiotic with some of the Algæ found round the shores of the North Sea, has already been demonstrated, and it seems possible that forms having a similar nitrifying action remain to be discovered in the open sea.

As they at present stand, the observations noted in this paper can at most be considered as offering a slight indication of the part played by certain bacteria in the metabolism of the sea.

To obtain a real insight into the question, it would be necessary to make extensive bacterial and chemical investigations in tropical, temperate, and Arctic seas, and more especially to make a study of the bacterial flora at different depths at some spot where considerable depth, unaffected by currents, could be obtained. The probability that bacterial growth plays an important part in causing the precipitation of certain bottom deposits in coastal waters, and conceivably also in the deep sea, is a subject that appears well worthy of further investigation.

The Problem of Sex Determination in *Dinophilus gyrociliatus*.

By

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THE group of primitive Annelids *Dinophilus* comprises some eight or nine species. They are remarkable for the fact that some show a well marked sexual dimorphism, in which the male is rudimentary, without any mouth or digestive tract, while in others the sexes are the same size and exhibit no signs of this dimorphism. The group as a class, therefore, is readily divisible into two subdivisions, in one of which all the species are sexually dimorphic, unpigmented, while in the other they are highly pigmented, a bright red, and are sexually monomorphic. The former may be called the Leucodinophilidae, while the latter may be called the Erythrodinophilidae. The known species, many of which are of doubtful specific value, may be arranged under these two subdivisions, as follows :—

Leucodinophilidae	1.	*Dinophilus*	*gyrociliatus*, Schmidt, 1857.
	2.	,,	*Conklini*, Nelson, 1907.
	3.	,,	*apatris*, Korschelt, 1882.
	4.	,,	*metameroides*, Hallez, 1879.
	5.	,,	*pygmaeus*, Verrill, 1892.
Erythrodinophilidae	6.	,,	*vorticoides*, Schmidt, 1848.
	7.	,,	*Gardineri*, Moore, 1899.
	8.	,,	*tæniatus*, Harmer, 1889.
	9.	,,	*gigas*, Weldon, 1886.

Of the Leucodinophilidae the first three species, *D. gyrociliatus*, *D. Conklini*, and *D. apatris*, are closely related, and are probably one and the same. The form on which the following work has been done is one of these three species, though exactly which of the three I have been unable to decide. I have placed it under the head of *D. gyrociliatus*, as this is the oldest of these names. Figures of the male and female drawn to scale, are shown in Fig. 1. It will be seen that the female is very much larger than the male, and that the sexual dimorphism is well marked. It was obtained some three years ago from some sandy material collected in Plymouth Sound. I introduced it subsequently into the tanks of the Plymouth Laboratory, where it has since established itself, and breeds.

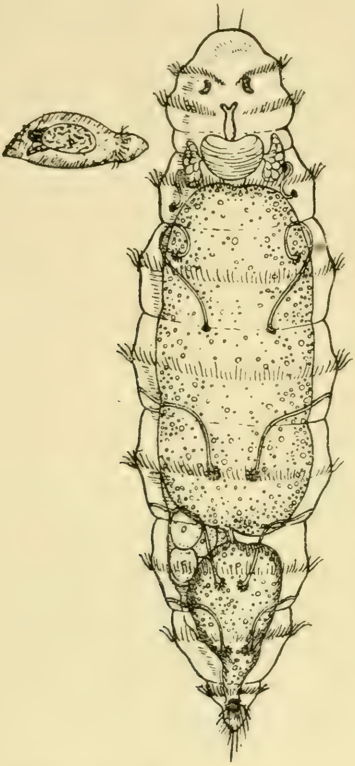

FIG. 1.—*Dinophilus gyrociliatus.* Rudimentary male and full-grown female. The female shows the broken nature of the ciliated bands in the head region and the solenocyte bearing nephridia.

Korschelt was the first to point out that a marked sexual dimorphism is present in *D. apatris*, where the male is small and rudimentary. He also observed that the female laid two kinds of eggs together in one capsule. Some of these were almost six times the size of the others, and were destined to give rise to the females, while the small ones gave rise to the rudimentary males. The large female eggs are laid in the proportion of three to one of the small male ones. Here is apparently a clear case in which we get sex determination in the ovary long before fertilization. Korschelt took it for granted that the eggs were only fertilized after being laid. The presence of this species of Dinophilus at Plymouth afforded me the opportunity of thoroughly investigating this question again, and of determining the manner of formation of these two kinds of eggs.

As Korschelt has determined, the two varieties of eggs are laid together, but they develop immediately without the presence of the male, and are therefore fertilized inside the body of the female. In a few days the small male egg gives rise to the rudimentary male, which at the time it is ready to leave the capsule is full-grown and sexually mature (Fig. 1). The female, on the contrary, when she leaves the capsule, is very small, and still in the larval state, the ciliation and arrangement of the segments being quite different from that in the full-grown condition, which is only attained after a considerable period, and may never be assumed if she does not happen to obtain proper food. Thus in culture jars in which food is not found, the females will remain as long as six months in an immature condition, and never grow up.

The young worms may be clearly watched within the capsule as segmentation and development proceed. The development is direct, and as the time for hatching approaches, the young larval females are seen to spin round within the capsule. This denotes that they are about to hatch and leave the capsule and commence their free existence. If the capsule is placed under the low power of the microscope at this stage and carefully observed, it will be seen that the little males are actively copulating with the small females at this time within the capsule. The actual transference of the sperm from the testis of the male through the penis into the body of the female can be distinctly seen. Every female as she passes out of the capsule is seen to carry a small mass of sperm, collected under the gut at the junction of stomach and intestine at the point where the ovary will subsequently appear. The rudimentary males seldom or never leave the capsule, dying shortly after the females escape. Examination of any immature free-swimming females, taken from culture dishes at random, always shows that they are all fertilized. If they are carefully fixed and sections cut from them at this stage, it will be seen that the germ cells have not been differentiated, and although a mass of sperm is collected at the point where the ova will subsequently appear, no trace of them can be detected. These only appear at a much later date, when the female has grown considerably in size. They are seen then as a few small refractive cells in the living state, and as small nuclei surrounded with hardly any cytoplasm in the stained condition, beneath the gut and amongst the mass of sperm. Shortly after they appear it is seen that each one is joined by a spermatozoon, the head of which has become embedded or attached to its nuclear wall, so that ultimately the nucleus of each primitive ovum is seen to be composed of one part derived from the spermatozoon, and the other part the female portion. These two elements of the nucleus never fuse, but retain their individuality throughout all the öogonial divisions. The double nucleus divides amitotically, each half separately. In the majority of the divisions the male and female portions of the nucleus divide equally, so that a similar quantity of nuclear material, both male and female, gets into each daughter cell. There are probably about forty to fifty öogonial divisions in all. In these the male and female portions of the nucleus divide and move apart simultaneously, the male portion usually dividing first. Now and again, however, the female half of the nucleus seems to divide before the male portion, so that the male portion gets left behind and is shut off entirely in one of the daughter cells. Therefore of the two resulting cells of this division, one has the whole of the male part of the original nucleus and its share of the female portion, while the other has only half the female and no male substance. This appears to be the sex determining factor; for of these two daughter cells, the one that has received the whole of the male element, plus the female element, becomes the female, while that which has received the female portion alone becomes the male. Both these kinds of eggs, once the sex determining division has taken place, grow rapidly. They seem to accomplish this through the power of absorbing and building up into themselves all the other immature egg cells with which they happen to come in contact, and in which the divisions of the two portions of the male and female substance has been equal. The outcome of this process is that the male egg is not fertilized, while the female egg is. It is, however, impossible to speak in the strict sense of the word of the male egg as unfertilized, as it has been directly under the influence of the sperm in all the early öogonial divisions previous to the sex determining one. For all the primitive germ cells are joined in the first place by a spermatozoon, irrespective of the fact that only some of these will give rise to ova later, and that the majority will be only nurse cells. It is only in the late stages, shortly before the female egg is laid, that the two portions of the nucleus, the male and female actually fuse beyond recognition. As the two kinds of eggs, male and female, are not found in a simple ratio, but in the proportion of three or two, to one male, it is probable that some other division takes place in the case of the female egg. I have been unable to decide this point so far, from my sections.

I have made a careful study of the maturation divisions, and as Korschelt has determined in *D. apatris*, there are two polar bodies given off by both kinds of eggs, the first polar body in turn dividing after it has been given off. There are twenty somatic chromosomes. In both eggs there is a regular reduction in the first maturation division, ten dumb-bell shaped chromosomes going out and ten remaining in the egg. In the female egg, however, this process is somewhat different from that in the male, as there seems to be something similar to a synapsis stage in the former which is missed out in the latter. In both eggs after the extrusion of the first polar body, the ten chromosomes remaining in the egg divide, bringing back the number to twenty again. In the second polar body, in the male egg, apparently twenty or eighteen chromosomes go out and the same number remain in the egg. The second maturation division in the female egg, I have been unable to obtain satisfactorily in sections so far, and it may prove that the second polar body in this egg is simply derived from division of the first, and that only one polar body is actually given off by the female egg. In the first and second segmentation divisions in both eggs there are apparently twenty chromosomes. It is, however, very difficult to make out their number in the male egg very accurately on account of their small size, there are at least eighteen or more, and probably twenty, as in the female egg.

The details of the maturation divisions I wish to reserve for my full paper on the subject, shortly appearing in the *Quarterly Journal of Microscopical Science.*

A Table showing certain Cultural Characteristics of some of the Commonest Bacteria found in the Laboratory Tanks at Plymouth.

By

G. Harold Drew.

THE following table is merely intended as a rough classification of eight of the most common species of bacteria found in the Laboratory Tanks. Only the forms which occur free in the water in the greatest numbers have been considered, and the moulds and higher bacteria which can be cultivated from scrapings from the walls of the tanks have not been included.

Until further and more detailed work has been done on the subject, it seemed better to designate the various species by numbers instead of names, since the majority have probably not previously been described.

The culture media employed were similar to those ordinarily used for bacteriological work, with the exception that fish broth (made from dogfish) was substituted for meat broth, and that sea-water was used in place of tap-water. All media were faintly alkaline to Neutral Red.

The medium designated as "Gran's medium," has the following composition:—

Sodium chloride	8·8 grammes.
Potassium nitrate	0·25 ,,
Sodium phosphate (Na_2HPO_4, 12 H_2O)	0·125 ,,
Calcium malate	in excess of its solubility.
Distilled water	250·0 c.c.

and is fully described by H. H. Gran in the *Bergens Museums Aarbog*, No. 3, 1901.

The sample of water, from which the bacteria classified in the table were isolated, was collected from just below the surface of one of the tanks in the upper Laboratory at 5.30 p.m. on December 6th, 1909. 0·1 c.c. of this sample plated on Fish-broth, Peptone Agar at 30° C., gave an average of 130 colonies of all kinds. Samples collected on other occasions show that the eight species described below may be considered as always present and abundant in the tank water.

TABLE SHOWING SOME OF THE DISTINGUISHING CHARACTERS OF THE COMMONEST BACTERIA IN THE AQUARIUM TANKS.

No	Morphological characters of bacteria grown in Fish broth, Peptone medium.	Appearance of superficial colonies on Fish broth, Peptone Agar at 30° C.	Stab cultures on Fish broth, Peptone Gelatin at 15° C.	Stab cultures on Fish broth, Litmus, Lactose, Peptone Agar at 30° C.	Stab cultures on Fish broth, Neutral Red, Glucose, Peptone Gelatin at 15° C.	Denitrification in Gran's medium at 15° C.	Further notes.
1	Actively motile rods with rounded ends, often appearing as diplo-bacilli. Length of rods about 1½ times diameter.	Circular brown colonies, becoming white at edge as growth proceeds. Slow growth. Margin smooth and regular.	Slight superficial growth; very faint growth along stab. No liquefaction.	Slight superficial growth; very faint growth along stab. No colour change.	Slight growth on surface and to within ¼ inch below; very faint growth in deeper parts. No colour change.	No growth.	Growth in media containing Lactose or Glucose was slightly though distinctly more rapid than in other media.
2	Actively motile rods and diplo-bacilli. Extremely small.	Circular white colonies, uniform, with denser spot in centre. Margin smooth and regular. Rapid growth.	Free liquefaction on surface. Free growth in deeper parts, but no liquefaction.	Moderate woolly looking growth all along stab. No colour change.	Strong growth all along stab. Liquefaction on surface. Acid formation.	Moderate growth. Nitrite formation recognizable after five days.	
3	Small actively motile vibrio.	Circular cream-coloured colonies, much elevated. Brownish spot in centre. Highly refractive. Margin smooth and regular. Rapid growth.	Uniform growth along stab. No liquefaction.	Uniform growth along stab. No colour change.	Uniform growth along stab. No colour change. No liquefaction.	Moderate growth, but no nitrite formation.	Growth in media containing Lactose or Glucose was more rapid than in other media.
4	Long spirillum, actively motile.	Large white colonies with irregular outline, denser spot in centre. Colonies rapidly spread over surface.	Very slight growth all along stab. No liquefaction.	Very faint growth near surface. No colour change.	Very faint growth near surface. No colour change or liquefaction.	Moderate growth, but no nitrite formation.	Presence of Lactose or Glucose appears to retard growth.

5	Small actively motile vibrio.	Circular white colonies with very granular appearance. Margin finely irregular. Colonies much elevated above surface, and of slow growth.	Free growth. Funnel-shaped area of liquefaction rapidly spreading downwards.	Growth all along stab. No colour change. Woolly appearance.	Free growth. Funnel-shaped liquefaction. No colour change.	No growth.	
6	Minute actively motile rods.	Large white, cloudy-looking colonies, circular with finely irregular outline.	Growth on surface only. No liquefaction.	No growth.	No growth.	Rapid growth, and denitrification apparent in four days.	
7	Small spirillum, non-motile.	White, translucent, highly refractive colonies. Circular. Margin smooth and regular.	Free growth all along stab. No liquefaction at first, but after five days it begins to appear.	Free growth all along stab. No colour change.	Free growth all along stab. No colour change.	No growth.	
8	Small actively motile rods.	Circular white colonies of very rapid growth, showing denser spot in middle. Uniform smooth margin. In old cultures the whole medium becomes of a golden-brown colour.	Rapidly developed funnel-shaped area of liquefaction, soon resulting in the complete liquefaction of all the medium.	Free growth all along stab. Woolly appearance. No colour change beyond slight reduction in deeper parts.	Rapid liquefaction with acid formation.	Rapid growth, and denitrification within four days. Ammonia formation apparent at fifth day.	Further experiments with Litmus Gelatin Peptone media containing Glucose, Lactose, Cane Sugar, Starch, etc., gave results which point to the conclusion that this is the *Bacillus repens* described in detail by H. Gran.

Note on the Early Larvæ of *Nephthys* and *Glycera.*

By

H. M. Fuchs, B.A.

With 10 Text-figures.

THE larva of *Nephthys* was originally described by Claparède and Mecznikow (2) in 1868, from specimens obtained from the Plankton at Naples. Since then it has been figured by Fewkes (3), Häcker (5), and Gravely (4). The larva of *Glycera* is, as far as I am aware, hitherto undescribed.

The larvæ described below were reared in the laboratory at Plymouth, at the suggestion of Dr. Cresswell Shearer, from artificially fertilized eggs. Both *Nephthys Hombergi* * and *Glycera convoluta* can be obtained from the sand in Jennycliff Bay at low water. *Nephthys* occurs more commonly than *Glycera*, but large specimens are not frequent. On the other hand, very young specimens are completely absent. It is at present altogether unknown what becomes of the young of these worms from the time when they sink down from the Plankton until they grow to about an inch in length. From June to August most of the larger individuals contain ripe sperm and ova, which are frequently discharged in captivity, within a day or two from the date of capture. It was found unnecessary, however, to wait until the generative products were shed naturally. The method of procedure was as follows: The worms were slit up with a pair of scissors and placed in "outside" sea-water in sterilized finger-bowls, the males being kept apart from the females. As soon as the sexual products emerged from the body cavity the worm was removed, several being treated in this manner to ensure the presence of ripe eggs. A few drops of liquid from the suspension of sperm was then added to the bowl of eggs and the latter stirred and allowed to settle. Wilson (9) has stated for *Nereis* and Treadwell (8) for *Podarke* that if the eggs are cut out of the body of the female, segmentation is irregular. This is not the case with *Nephthys* and *Glycera*. As soon as the larvæ swam to the surface they were pipetted off and placed in jars of filtered sea-water.

All attempts to feed the larvæ failed, and in consequence, although they could be kept alive for three weeks or a month, after about

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* It is just possible that a few small specimens of *N. caeca* were included with the *N. Hombergi*.

fourteen days no further development took place. I have to thank Dr. Allen for providing me with pure cultures of Diatoms and other Algæ, but I was unable to find any food which the larvæ would eat. Nothing is easier than the rearing of Serpulids in a laboratory, and especially is this the case with regard to *Pomatoceros*, which is a hardy shore form, found growing even at the mouths of drains. It breeds naturally and in great profusion in the tanks at Naples, the young worms settling down and forming their tubes without having any care bestowed on them. But very few of the free-living Polychaetes have been reared to a late stage. *Chaetopterus* is an example of one which has been raised (Allen and Nelson 1) and Lillie (6) was successful with *Arenicola*. I have found it very easy to rear the larvæ of *Nereis dumerilii*, which are derived from yolky eggs, as far as thirty segments or more. Quite otherwise, however, is it with those free-living Polychaetes which have a pelagic larva. It would thus seem that it is possible to rear from the egg such forms as the Serpulids, which have a typical Trochophore, and those which have yolky eggs, but no method has as yet been devised by which the majority of the errant forms can be fed and raised.

The egg of *Glycera* is discoidal, and it does not swell up in sea-water. It is granular, but comparatively transparent, with a lighter coloured nucleus. The egg of *Nephthys* is also flattened at the poles, but is opaque. The cleavage is equal.

Unlike the larva described by Claparède and Mecznikow (2), the larva of *Nephthys Hombergi* is granular and so opaque as to render the study of the internal organs in optical sections very difficult. Neither in shape nor in transparency can it be called a typical trochophore. An early stage is shown in Fig. 1. The upper hemisphere is more conical

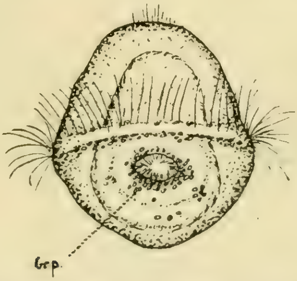

FIG. 1.—Larva of *Nephthys*. 2 days.
From the ventral aspect. *br. p.*—Brown pigment.

and of smaller diameter than the lower, and is surmounted by an apical patch of cilia. The mouth is situated mid-ventrally on the lower hemisphere, and strong cilia can be seen working within it. Brown pigment is scattered on the surface in small chromatophores, which are concentrated below the trochal ring and round the mouth. Fig. 2 shows a later stage, the general shape of the larva being the same as before. The alimentary canal is divided into stomach and intestine, and there is an anal patch of cilia. Fig. 3 shows a trochophore of four-

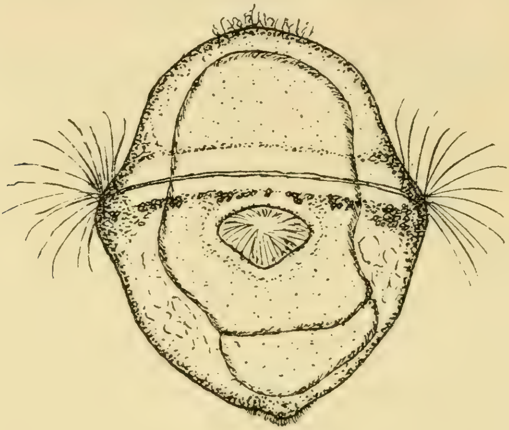

Fig. 2.—Larva of *Nephthys*. 6 days.
From the ventral aspect.

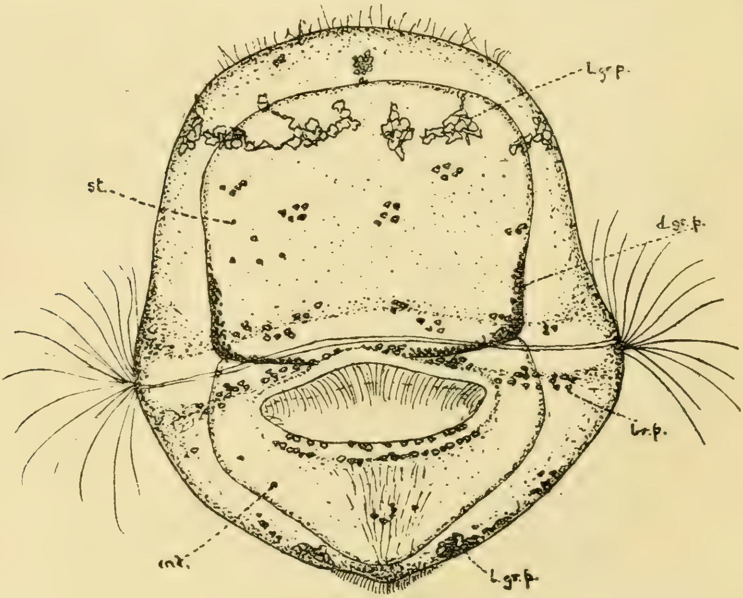

Fig. 3.—Larva of *Nephthys*. 14 days.
From the ventral aspect. *br. p.*—Brown pigment. *d. gr. p.*—Dark green pigment. *int.*—Intestine. *l. gr. p.*—Light green pigment. *st.*—Stomach.

teen days old. The upper hemisphere is larger and blunter than the lower. There is a patch of cilia extending from the lower lip of the mouth towards the anus, which is terminal. The apical cilia are usually motionless. Light green pigment has appeared in an incomplete band round the upper hemisphere, and a pair of patches on either side of the anus. These latter are characteristic of the larva of *Nephthys* (3). The large stomach, which fills the greater part of the upper hemisphere, has a dark green pigment in its basal walls, the remainder of the gut being yellow in colour. The intestine is sac-like.

The larva described above differs very much from that figured by Claparède and Mecznikow (2). It resembles in some points that of Fewkes (3), but is of a different shape. Häcker (5) and Gravely (4) described the Metatrochophore and later stages only.

Swimming blastulæ of *Glycera convoluta* appear some ten hours after fertilization, and the trochal ring is formed in twenty-four hours. An early larva is shown in Fig. 4. It is spherical and granular with a ciliated trochal ring and an apical tuft of long cilia. Fig. 5 shows

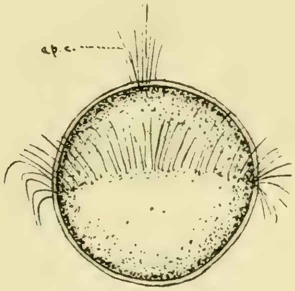

FIG. 4.—Larva of *Glycera*. 26 hours.
ap. c.—Apical cilia.

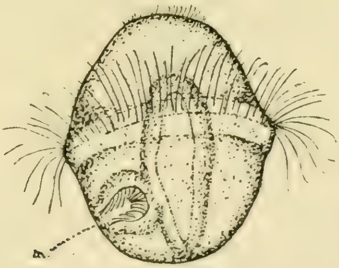

FIG. 5.—Larva of *Glycera*. 58 hours.
Left side view. *m.*—Mouth.

a somewhat later larva in lateral optical section. The larva is more elongated and the apical patch has become diffuse, without any long cilia. The buccal aperture is seen to be strongly ciliated. Fig. 6 is a trochophore of three days old. Little weight can, however, be attached to the ages of the larvæ, as in the same culture some larvæ, probably those which have developed from more mature eggs, will grow much more rapidly than others. At this stage the gut has thick walls, and there is a constriction between the stomach and intestine, which is much more evident than in later larval life. A very light green pigment is scattered over the surface. The apical patch seems to contain a pair of vibratile organs (Fig. 7), the significance of which is unknown.

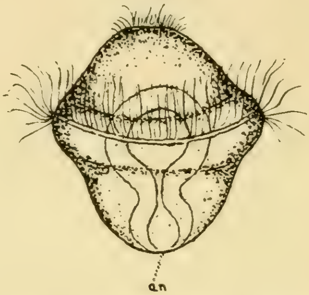

Fig. 6.—Larva of *Glycera*. 3 days.
From the dorsal aspect. *an.*—Anus.

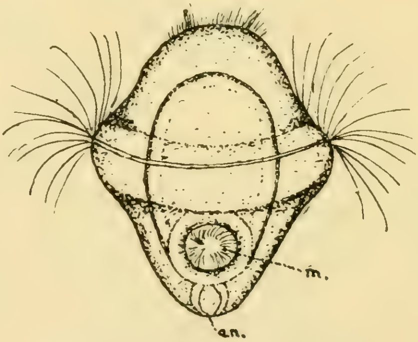

Fig. 7.—Larva of *Glycera*. 4 days.
From the ventral aspect. *an.*—Anus. *m.*—Mouth.

Fig. 8 shows the typical shape of this larva. The upper hemisphere is rather more conical and less dome-shaped than the lower. This is the reverse of the condition in a typical trochophore. Large and granular green pigment corpuscles are scattered over the surface. They are

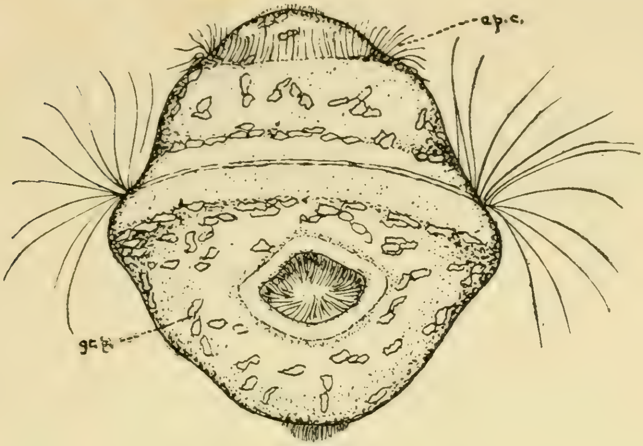

FIG. 8.—Larva of *Glycera*. 3 days.
From the ventral aspect. *ap. c.*—Apical cilia. *gr. p.*—Green pigment.

more numerous on the lower hemisphere, and especially below the trochal ring. The apical cilia have assumed the form of a ring round the upper hemisphere. This band is situated in a slight depression of the surface and is incomplete dorsally (Fig. 9). There is a patch

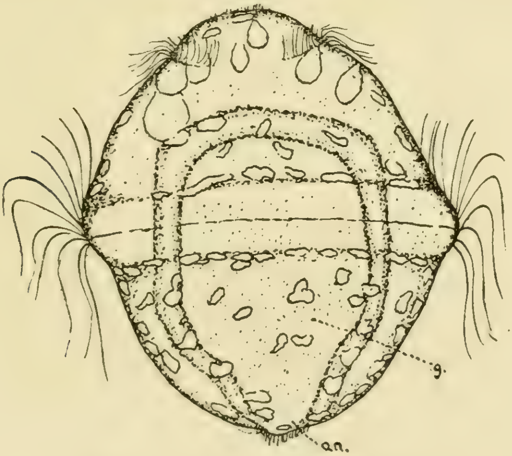

FIG. 9.—Larva of *Glycera*. 4 days.
From the dorsal aspect. *an.*—Anus. *g.*—gut.

of cilia extending from the lower lip to the anus (Fig. 10). The mouth is diamond shaped and is situated mid-ventrally on the lower hemisphere. The gut is large and sac-like, without any definite division into stomach and intestine.

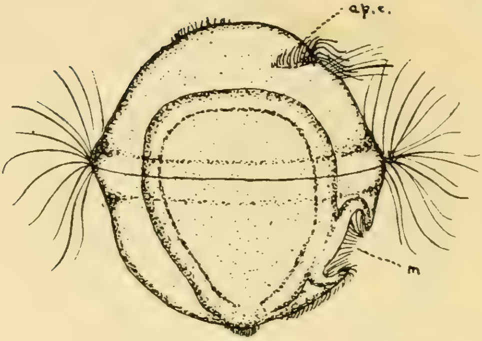

Fig. 10.—Larva of *Glycera.* 10 days.
Side view. *ap. c.*—Apical cilia. *m.*—Mouth.

As has been pointed out by Shearer (7), the typical Trochophore is confined to a very limited number of Annelids, occurring, in fact, only in Serpulids and *Polygordius.* The larvæ of the remaining forms, which have a pelagic stage, mostly resemble the two described above. They differ from the true Trochophore in form, opacity, shape of the gut, in the absence of a head-kidney and in the small amount of blastocoele. The early *Nephthys* larva figured by Claparède and Mecznikow (2), however, seems to approach closely to the form of a true Trochophore. They state that a whole series of intermediate forms were collected from the Plankton, up to the stage when the bristles were recognizable, so that there could be no doubt of the identity of the larva. Later observers, however, have described quite another type of larva for *Nephthys,* and one closely approaching that of *N. Hombergi.*

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The Relation of the Heart-Beat to Electrolytes and its Bearing on Comparative Physiology.

By

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An objection often raised to experiments on tissues treated with artificial solutions and isolated from nervous control is that results obtained under such highly abnormal conditions can be of no real value. This criticism arises essentially from a misconception as to the aim of the experiments in question, but it is encountered so frequently that it may not be out of place to consider briefly why it is *necessary* for the physiologist who would learn something of the more intimate mechanism of the cell to work with tissues under artificial conditions.

Let us suppose that the action of some chemical substance on the heart-beat is the subject of investigation. It is found, we will suppose, that on injecting a solution of the substance into the circulation of an intact animal the beat of the heart is modified in some way—it may be in frequency or force, or in the rhythmic sequence of its chambers. If on repetition of this simple experiment, made on animals as far as possible under normal conditions, the same result is consistently obtained, the result may be of therapeutic interest. For its interpretation in terms of what is already established about the mechanism of the body, a searching physiological analysis is, however, required. The effect on the heart may be direct or it may be due to one of a variety of indirect actions of the substance.

Thus, for instance, it may be due to an action of the substance—

(1) on sensory nerve endings connected to the cardio-inhibitory or cardio-accelerator centres in the medulla;
(2) on the nerve cells in these centres;
(3) on cell stations in the course of the vagus or sympathetic nerves to the heart;
(4) on the respiratory movements, modification of which affects the condition of the blood in such a way as to influence the heart, either directly or through action on the nerve centres which can control it;

(5) through an alteration in the blood pressure (which may affect the heart by a local or a central point of attack) due to constriction or dilatation of arterioles, this being caused either by reflex, central or local action;

(6) on the heart muscle itself.

By an elaborate series of experiments, involving the section of nerves, the use of drugs such as atropine and curare, the enclosure of organs in plethysmographic apparatus; by taking records of blood pressure and by ventilating the lungs steadily with the aid of a mechanically-driven respiration pump, it would be possible to determine by which of the various possible means the effect of the injected substance on the heart was produced.

Suppose, now, that by such experiments the point of action of the substance has been traced to the heart muscle itself. (Be it noted that the elucidation of this point has involved the imposition of more and more artificial conditions.)

The experiment remains of comparatively little value to the physiologist, who is endeavouring, by the investigation of the effects of substances on the activity of the heart, to learn more about its actual mechanism. For the experiment can only in the vaguest sense be called quantitative. However carefully the dose of the drug is weighed out, the concentration of the substance in the blood reaching the heart cannot be known at all accurately, since the dilution depends not only on the rate at which the injection is made and on the rate of flow in the vein into which the injection is made, but also on the blood flow in all the other veins leading to the heart. Moreover, it is seldom justifiable to assume that the injected substance remains unchanged in the blood. Blood is a highly complex fluid: the carbonates, phosphates, and in particular the proteins present in it, enter into chemical or adsorptive relation with many injected substances. Of course, from a therapeutic standpoint this does not matter. If, for instance, the injection of a particular drug is followed by marked strengthening of the heart-beat, it matters little to the practitioner whether the substance actually presented to the heart as a result of his injection is the same chemical substance as that which left the hypodermic syringe, or a product of some complex reaction between that substance and the blood or tissue fluids. But when the object is not simply the production of the effect, but the explanation of how it is produced; when the response of living cells to changes in their chemical environment is being used to throw light on the mechanism and properties of the tissues themselves, it is clearly of the first importance that the change in the environment in any experiment should be known with the utmost precision.

Practically every experiment involves the imposition of some abnormal conditions. In a state of nature, conditions are varying continually; the fixation of any condition in itself constitutes an abnormality. After determining artificially one condition, it is fallacious to speak of the remaining conditions as being "normal." If they too are not experimentally controlled, they are unknown. The choice lies, therefore, between a type of experiment in which most of the conditions are unknown but where there has been but little operative interference, and another type where the conditions are simplified and controlled by artificial means. The former may yield information of much value to the physician, but it is to the latter that we must turn for advances in our knowledge of cell physiology.

If, now, we are concerned with the problem of how and why the heart gives rhythmic contractions, the first step will be to determine and to define the simplest conditions under which the heart will continue to beat. Removal of the heart from a freshly killed animal suffices to show that the essential mechanism is self-contained. The movements of the heart, though susceptible of control by the central nervous system, are yet able to continue when all nervous connection is severed, and indeed it is known that in the chick they begin in the heart muscle some time before any nervous connection is established. It might be suggested that the excised heart lying in a watch-glass and continuing to beat was under the simplest conditions imaginable. Very little consideration is needed to show that this is not the case. In the first place, its temperature is not being controlled; and secondly, the heart muscle is in contact with a layer of fluid of complex and changing composition. As so often in scientific work, an elaboration of apparatus is necessary in order to secure a simplification of experimental conditions. That the composition of the fluid in contact with the muscle may be known as closely as possible it is desirable that a large volume of the fluid should be available, and that the portion in contact with the tissue shall be frequently renewed. For this purpose it is not sufficient to immerse the heart, or portions of it, in a large vessel of the solution. Such a method, it is true, has often been adopted, but it is far from being satisfactory. The best method is to perfuse the heart with fluid, letting the solution enter the venous end of the heart at a small and constant pressure, and allowing it to escape at the aortae, which may be opened up to allow of a free flow. In this way, in the hearts of animals, where the coronary system has attained to no great development,* the heart muscle, and in particular that of the thin-walled auricles and sinus venosus, is brought into very intimate relation with a constantly renewed layer of fluid. The stream of fluid may be said to control the temperature and the chemical environment of the cells. The efficiency of the perfusion method is shown by the fact that with a suitable fluid the heart may be kept beating regularly and strongly for many hours, while slight changes in the composition of the perfused fluid with respect to an important ingredient are followed by evident change in the character of the beats within a very few seconds.

As might be expected, the blood or serum from the animal whose heart forms the subject of experiment forms a perfusion fluid effective in maintaining the activity of the heart. But the classical researches of Ringer revealed the all-important fact that these highly complex, protein-containing solutions could be satisfactorily replaced (in the case of the frog's heart) by certain solutions of simple inorganic salts. The presence of the inorganic salts of the serum in the fluid in contact with the cells of the heart muscle is of more immediate importance for the activity of these cells than is the presence of any organic food-stuffs. It is true that it has been shown that the addition to the salt solution of a small amount of glucose keeps the heart going for longer periods than are attained without it; and according to some the addition of proteins has a beneficial effect, though this is denied by others who have studied the point. The fact remains that with a solution of simple inorganic salts in distilled water containing some dissolved oxygen the hearts of various animals can be kept beating outside the body for very many hours.†

During this time, while the heart continues to contract regularly and with sufficient force to enable it to pump through fluid with such energy that if it were still connected to the arteries it could fulfil its normal function of propelling fluid through the vascular system, and while the frequency and form of the contractions remain essentially like those observed in the heart of the uninjured animal, we may say that the heart muscle is exercising its normal function, and although the conditions are frankly abnormal in many respects, yet they embrace those factors of environment which are *immediately* necessary for the normal behaviour of the cardiac muscle cells.

We must next consider what are the essential constituents of a salt solution which will answer this purpose.

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* In mammalian hearts it is necessary to perfuse the coronary system.

† In working with the hearts of Elasmobranchs, as Baglioni (Zentralbl. f. Physiol. 19, 385, 1905) showed, it is necessary to add urea to a neutral perfusion fluid.

The "Ringer's solution" most commonly employed in the physiological laboratory contains chiefly sodium chloride with small quantities of potassium and calcium chlorides and of sodium hydrogen carbonate. The actual concentrations of the salts employed differ according to the animal used; for the frog the total concentrations should be about ·125 Mol. If the concentration of sodium chloride be called 100 the relative concentrations of the other salts may be taken as 2·5 of potassium chloride, 2 of calcium chloride, and 1·5 of sodium hydrogen carbonate. This solution, simplified by the omission of the last-named ingredient, still maintains the heart-beat in a satisfactory manner. We shall return in a moment to the function of the sodium bicarbonate. Its presence is not essential. Removal of the potassium salt leads to an alteration in the character of the beats, the systolic phase becoming prolonged, but does not necessarily cause arrest or even weakening of the beats. With a solution consisting only of distilled water with sodium and calcium chlorides and some dissolved oxygen, if the concentration of the Ca is carefully adjusted, the frog's heart may be kept beating vigorously for prolonged periods.

Removal of the calcium from the perfusion fluid is immediately followed by great weakening of the contractions, which in the course of a few minutes become exceedingly feeble and before long cease altogether, the heart remaining in a relaxed state. When the calcium is replaced the beats start again at once and become as vigorous as at the start. In the frog, as Ringer showed, the calcium may effectively be replaced by strontium. It may also be replaced by barium, but only to a very limited extent, for in a short time barium causes arrest of the heart in a firmly contracted state.

It should be noted that practically *any* soluble salt of calcium may be used in place of the chloride. The ionic theory is peculiarly acceptable to the physiologist in that it gives concrete expression to the fact so often encountered, as here, that all solutions of a particular metal, where on physico-chemical theory it should be in the same ionic condition, present in common certain definite physiological actions. We may say that the calcium ion is essential for the activity of the heart. There is reason to think that the calcium forms with some constituent of the heart muscle a readily dissociated compound, whose presence is a cardinal factor in the activity of heart muscle. The closely similar strontium ion can form a compound so similar to the calcium compound that it can fill the same niche in the architecture of the muscle, while the barium ion may best be pictured as forming a compound of similar composition but probably almost irreversible, perhaps through great insolubility. No metal other than these has been found to replace calcium.

It is of interest to find that these relations of the heart muscle to Ca, Sr, and Ba are essentially the same, not only in other vertebrates which have been studied, but also in the heart of the mollusc Pecten.

So far then the features of immediate importance in the perfusion fluid for the heart appear to be the presence of certain concentrations of sodium and of calcium ions, the presence of dissolved oxygen and the maintenance of the temperature within certain limits.

Keeping these conditions constant, let us consider the effects of varying the composition of the fluid in certain other respects.

Since we deal always in physiological work with aqueous solutions, and since water is to a slight extent electrolytically dissociated, our solutions always contain hydrogen ions and hydroxyl ions. In pure water these are of course present in equal numbers, the concentration of each, expressed in gram-ions per litre, being at room temperature about 10^{-7}.

It follows directly from the general principle expressed in the law of mass action that the addition to the water of any substance tending to increase the concentration of hydrogen ions will reduce the concentrations of hydroxyl ions. A similar shift in the equilibrium will be produced by the addition of any substance tending to remove hydroxyl ions. The ratio of the $H^{\cdot}$ to OH' is increased. An inverse change is produced by the addition of OH' or the removal of $H^{\cdot}$.

Knowing the dissociation constant of water, if the hydrogen ion concentration of any aqueous solution is given it is a matter of simple arithmetic to calculate the hydroxyl ion concentration and the ratio between the hydrogen and hydroxyl ion concentrations for that solution.

To define the position of this $H^{\cdot}$, OH' equilibrium for any solution it is sufficient therefore to state the hydrogen ion concentration of the solution. This is expressed most conveniently as a logarithm.

To avoid the constant repetition of the phrase "hydrogen ion concentration" we may adopt Sörensen's notation in which the symbol P_{H}^{+} is followed by the logarithm of the hydrogen ion concentration, the minus sign being understood. Thus describing a solution as being of P_{H}^{+} 7·07 means "the hydrogen ion concentration of the solution is equal to $10^{-7\cdot07}$ gram ions per litre."

An aqueous solution whose P_{H}^{+} at 18° C. is 7·07 is neutral in reaction. If the P_{H}^{+} is numerically less than 7·07 the solution is acid, if greater it is alkaline. For instance, the P_H^+ of centi-normal hydrochloric acid is 2, that of milli-normal sodium hydroxide 11, and so forth. Now the solution of pure salts of strong acids and strong bases in distilled water, neutral by intention, becomes in the course of preparation very faintly acid as it reaches equilibrium with the small concentration of CO_2 present in the air. The reaction of pure water or of a solution of salts of the type we have just mentioned, which do not themselves affect the reaction, is very easily shifted by minute additions of acid or alkali. Thus one drop (·05 c.c.) of normal hydrochloric acid would suffice to change the P_H^+ of fifty litres of water from 7 to 6. But if the originally neutral solution contained a weak acid balanced against a salt of the same weak acid with a strong base, the addition of the same amount of acid as before would not appreciably disturb the P_H^+. Such a condition is realized, for example, in a saline solution containing a little sodium bicarbonate and carbonic acid. Such a solution may be prepared with the same P_H^+ as the purest water: it will differ from water in that its P_H^+ is much more stable—that is to say, it is displaced very much less by the addition of the same small traces of acid or of alkali. Substances having this effect on addition to a solution are spoken of by Sörensen as "buffers." Amphoteric electrolytes such as the amino-acids and their compounds the proteins tend also to stabilize the reaction of solutions in which they are present. The explanation of the action of all these substances lies in the fact that when they are present in a solution the hydrogen ion concentration is a function of more than one equilibrium. It should be noted in passing that in nature such "buffers" play an important rôle. For instance, the carbonates, phosphates, and proteins in the blood serve to limit the changes in P_H^+ of that fluid resulting from the production of acid metabolites by the tissues, the secretion of acid or of alkaline fluids, and the removal of carbonic acid in the lungs, to such values that the limits of safety are never passed. If the blood could be deprived of these substances, it is probable that the acid produced in moderate exercise for example would so raise the $H^{\cdot}$ concentration as completely to disorganize nerve cells and heart, instead of altering it only to such an extent as to cause the blood to act as a chemical messenger or hormone, modifying the activities of nerve cells and heart in such a way as to restore the normal value of the P_{H}^{+} of the blood. For this is what happens in actual life.

The action of acids and alkalies on the heart was described by Gaskell nearly thirty years ago. Let us note in detail the effects of acid. Gaskell used lactic acid, but the description he gave of its action on the heart applies equally to the effect of other acids, such as hydrochloric or even carbonic. The action on the heart is due to what they have in common: an excess of the hydrogen ion. The essential features of the action on the heart are these: The acid solution diminishes the force of the systole, increases the diastole, and causes arrest of the heart in a state of complete relaxation. If now the acid solution is washed out with "neutral saline" (i.e. P_{H}^{+} about 6·5),* there is no recovery for some time, and then very feeble beats may start. But if a slightly alkaline solution is used the recovery is prompt, and the beats become as strong as at the start within a few seconds, or at most in a minute or two. Further experiment shows that the persistence of the after effect of the acid bears a definite relation to the P_{H}^{+} of the acid solution and to the duration of its application. With a minimal dose of acid applied for the shortest time necessary to cause arrest of the heart, recovery on perfusion with "neutral saline" may be fairly prompt and complete, but if the dose is rather greater or applied longer the effect may persist for an hour or more during subsequent perfusion with neutral saline. This is to be regarded as the typical effect of acid on the heart. If the solution is made too alkaline the heart is also stopped, but in this case in systole. In the case of the frog's heart the divergence from neutrality needed to produce the systolic *alkaline* arrest is much greater than that needed to produce the diastolic *acid* arrest. Roughly, the limits are about P_{H}^{+} 10 and P_{H}^{+} 5·5 respectively. It is not surprising then to find that "neutral saline" restores the heart from the alkaline arrest much more quickly than from the acid arrest, for this solution is much nearer the "acid" limit than the "alkaline" limit.

So far then we have these facts. *The normal activity of heart muscle (by which we mean its power of giving automatic rhythmic contractions) is possible only when the hydrogen ion concentration of the solution in contact with it lies within certain limits. If these limits are considerably exceeded on the acid side, not only is the heart stopped, but some alteration is impressed on the muscle, which is removed only very slowly, if at all, by a "neutral" solution, but instantly by an alkaline solution.*

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* The slight deviation from strict neutrality is due to CO_2 from the air. It is convenient to use such a solution and it will maintain the heart-beat for hours.

In working at the action of salts on the heart I was led, for reasons which need not be entered into here, to investigate the action of salts of the rare earth metals such as lanthanum, yttrium, neo-dymium—in all eleven were studied.

These salts in aqueous solution yield trivalent ions, $La^{\cdot\cdot\cdot}$ $Nd^{\cdot\cdot\cdot}$, etc. Unlike the salts of other metals yielding simple trivalent ions (such as aluminium, gold, iron, etc.), these salts of the rare earths do not render the solution acid in reaction—they do not undergo hydrolytic dissociation. I found that remarkably small concentrations of these salts in "neutral" solution sufficed to stop the heart. Thus the frog's heart is invariably stopped within a few minutes, generally within thirty seconds, by a solution containing ·00001 gram molecules per litre of either of these rare earths, and I have often seen it stopped by a concentration of one-millionth molecular. I find the same action on the heart of the rabbit and of the ray as on that of the frog.

Studied in detail on the frog's heart, *the effect of the simple trivalent ion parallels that of acid in every particular. The mode of arrest, the absence of recovery, or the slow and imperfect recovery on washing out with "neutral saline," and the immediate and complete recovery on the use of alkali, are all reproduced exactly.*[*]

How are these phenomena to be interpreted?

Can we discover any physico-chemical explanation for the close similarity in their action on the heart of these ions, the hydrogen ion and the ion of the trivalent rare earth, which are so different chemically, so widely different in their mobilities and their volumes?

Let us first review very briefly what other considerations have led physiologists to infer as to the nature of that subtle mechanism by which muscular tissues like that of the heart transform chemical into mechanical energy with such high efficiency.

The recent work of A. V. Hill on the time relations between heat production and shortening in muscle disproves the hypothesis that the shortening is an effect due to the action of local rise of temperature on some constituent of the muscle structure. The muscle is certainly not a heat engine.

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[*] Quantitative investigation shows that these simple trivalent ions are more powerful than the chemically equivalent concentration of hydrogen ions in their effect on the heart. And thus it happens that if the activities of solutions yielding trivalent ions which do undergo hydrolytic dissociation are compared with those which do not, the latter are found more powerful in their action on the heart. For instance, taking equimolecular solutions of aluminium, scandium, and lanthanum chlorides, the $Al^{\cdot\cdot\cdot}$ liberated in the first solution combines to some extent with the OH' in the water, forming an almost undissociated hydroxide and liberating an equivalent of $H^{\cdot}$ (3 $H^{\cdot}$ for every $Al^{\cdot\cdot\cdot}$). Thus the solution becomes acid. In the lanthanum solution there is no hydrolysis, for lanthanum hydroxide is strongly dissociated. Thus the solution remains "neutral," and contains its full complement of $La^{\cdot\cdot\cdot}$. The case of scandium is intermediate: its solution is less acid than the Al solution. Now it is found that while all three solutions produce the same kind of effect on the heart, the lanthanum solution is the most and the aluminium solution the least powerful of the three.

The so-called osmotic theory of contraction—which supposes that as a result of the liberation of a high concentration of electrolytes within certain membranous compartments of a particular shape, an increase of hydrostatic pressure is set up within them causing them to bulge and shorten, thus producing the shortening of the whole muscle—meets with the objections that the osmotic pressure which would be necessary to give rise to mechanical effects of the magnitude encountered in muscular contraction would necessitate extraordinarily high concentrations of electrolytes, and such changes could scarcely be completed in the very brief interval which often suffices for the completion of a muscle twitch.

The sort of explanation which has most to recommend it is that which refers the act of shortening to a mechanism in which the alteration of surface tension at the junctions of different phases is the motive power. Anyone who has studied the behaviour of a globule of mercury, lying in a dish of dilute sulphuric acid to which a trace of potassium chromate has been added, when touched by a clean iron wire, will recognize in the sudden drawing together of the globule movements which recall more forcibly than any other artificial scheme the movements of living contractile tissue. Here, too, the evolution of a considerable amount of kinetic energy is the result of a very small amount of chemical change.

As to the mechanism by which surface tension alterations can be supposed to play a part in the muscle, there are two chief hypotheses. Both suppose that as a result of the process of excitation in the muscle there is a liberation of excess of some electrolyte in the tissue. According to one view, an ion of this electrolyte combines chemically with some protein constituent of the muscle to form a new ion-protein compound possessing different physical properties—the protein being so disposed in the muscle that an alteration in its surface tension will exert a pull on the whole structure and lead to shortening.

Another view is that the electrolyte is liberated in a system presenting surfaces possessed of differential permeability towards the ions and that thus the liberated electrolyte sets up differences of electrical potential across these surfaces resulting in mechanical strain and alteration in the contour of these surfaces. This last view, though it is at present of necessity somewhat vague, has on the whole more to recommend it than either of the others. The electrical phenomena which accompany the contraction as well as the excitation processes in muscle provide important evidence, and other facts might be adduced in favour of the idea that an essential part in the mechanism of the contractile process in muscle is played by surfaces or membranes possessed of differential permeability towards ions. It is familiar that such membranes form an integral part in the theories of *excitation* propounded by Nernst and elaborated by Lapicque and by Lucas and Hill.

The existence of membranes or surfaces in muscle is granted by the histologist to almost any desired extent. In the case of skeletal muscle indeed, it is scarcely an exaggeration to say that every histologist who has undertaken the investigation of its structure has described and attached his name to some new membrane, line or band.

It is clear then that we are not making any new or rash assumption in stating that *certain surfaces or membranes form an integral part of the muscle mechanism, and the ionic permeability of these membranes* is a factor of importance in that mechanism.*

The possession by a membrane of differential ionic permeability is no imaginary attribute: simple experiment shows it to be a very usual property. This fact is brought out most clearly by experiments on the influence of membranes on concentration cells.

Direct experiment shows also that the ionic permeability of membranes—and a great variety of them have been tested—is profoundly influenced by certain features of the solutions in contact with them. For a given membrane the factors likely to influence its ionic permeability are—

(1) The $P_{H}+$ of the solution with which it is treated.

(2) The presence in that solution of polyvalent ions. The simple trivalent positive ions are enormously more powerful than the divalent.

When a membrane such as a piece of peritoneal membrane, the lining of an egg-shell or a thin sheet of gelatine, is treated with a very small concentration of acid, or of one of the simple trivalent ions of which we have spoken, its ionic permeability is modified. Direct experiment shows that this altered condition is retained, it may be for minutes or hours, while the membrane is washed with a " neutral " solution free from the polyvalent ions—the persistence of the effect depends on the nature of the membrane, the concentration of the solution used to produce the alteration and the length of time it was allowed to act—but if the membrane is treated with a faintly alkaline solution the effect of the acid or the trivalent ion is removed at once.

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* Here and in the following pages we employ the word membrane with the understanding that it need not necessarily mean anything more than the surface of separation between two phases in the system.

The parallel with the action of these same agencies on the heart is sufficiently striking. And the parallel does not end here.

Seeking to test further whether this potent action on the heart is indeed a general property of trivalent ions, I employed solutions of certain cobaltammines which yield complex trivalent ions in neutral solution. The compound used most frequently was luteo-cobalt chloride $[Co(NH_3)_6]Cl_3$, which yields the ion $[Co(NH_3)_6]^{\cdot\cdot\cdot}$. Through the generosity of Prof. Werner I was able to test also four other complex trivalent ions. All agreed in showing very much weaker action on the heart than the rare earth solutions. A concentration of the complex ion of the order of 1000 times as great as of the simple ion is needed to stop the perfused heart. A similar difference is shown in the action of these ions on the gelatine membrane. Even large concentrations have only a slight effect on the ionic permeability of a membrane of this type.

The influence of hydrogen ion concentration and of trivalent kations on the heart is paralleled in detail by the action of these ions on the ionic permeability of certain artificial membranes.

The ionic permeability of a membrane can be shown, both theoretically and experimentally, to depend—other things being equal—on the electric charge of the membrane.

Now it can be demonstrated by a variety of methods that most membranes in water, or in a solution like our "neutral saline," possess a negative charge. This charge is reversed with great ease by acid or by the rare earth solution. This can easily be shown, for instance, by the use of dyes, which are themselves charged colloids. A piece of gelatine soaked in "neutral saline" stains very feebly with eosin, strongly with methylene blue. But after treatment with acid or rare earth it takes up eosin with great avidity and is hardly tinged by methylene blue. Eosin consists of negatively charged particles, methylene blue of positively charged particles. If the membrane has a negative charge it can hold the latter, if a positive charge, the former. This method also reveals the fact that the complex trivalent ions are much less potent than the simple trivalent ions in altering the charge of the gelatine membrane.

In these membranes we are, of course, dealing with substances in the colloidal state. If instead of using extended sheets of material we turn our attention to colloidal solutions, where one phase of the colloidal system consists of discrete particles floating freely in the other, it is possible to study the action of electrolytes more simply still. For in such systems the alteration of electric charge on the particles is often followed by an alteration in their state of aggregation, which may be manifested as an alteration in the colour of the solution, or as is very usual by actual precipitation. For instance, when the particles are negatively charged, as in colloidal gold or in a solution of egg-white, the addition in suitable concentrations of electrolytes capable of conferring positive charges on the particles causes agglutination of these particles.

Testing a large number of colloidal solutions by this method, it becomes apparent that there are great differences in the relative efficiencies of different ions in affecting the charge of different surfaces. Thus considering the simple and the complex trivalent ions one finds that many colloidal solutions are quite as readily precipitated by them as by the simple trivalent ions (e.g. colloidal gold, arsenious sulphide, boiled diluted egg-white, and many more), while others which are readily precipitated by the simple trivalent ions are unaffected by even large concentrations of the complex ions (e.g. unboiled diluted egg-white, haemoglobin, etc.). Of a large number of colloidal solutions, those which are very sensitive to complex as well as to simple trivalent ions are found to belong to that class of colloids known as lyophobe or suspensoid; those sensitive to the simple but insensitive to the complex trivalent ions, to the class called lyophil or emulsoid.

Clearly, what has been stated would indicate that the membranes in the heart muscle are of an emulsoid colloidal material. This indeed confirms in one special instance a conclusion drawn from entirely different considerations by Martin Fischer as to the nature of the body proteins in general. The study of the action of these electrolytes on the heart will give more precise information than this. When the ratios of the activities of the simple and the complex ions on surfaces of various compositions have been worked out in detail, we shall be enabled to define precisely some physico-chemical constants for each surface. As has been remarked, the investigations of colloid chemistry have not as yet been carried far enough for this to be done, but the methods are available, and the research would present no insuperable difficulty. Just as the classification of liquids of two phases into suspensions, colloidal solutions and true solutions, is now recognized to be an arbitrary though convenient subdivision, there being no real boundaries between the classes; so it will probably be found among the colloidal solutions themselves. We shall learn in course of time to describe each colloidal solution in terms of certain essential factors which will include such terms as the viscosity of the phases, the amount of surface presented by them, and the electric charge they carry. At present this cannot be done in any quantitative sense, yet we may illustrate from material already available the nature of the biological interest which will accrue from knowledge of this kind.

In the first place, new light is thrown on the relations between the living heart muscle and its normal environment.

We have considered the importance of the $P_{\mathrm{H}}+$ of the solution. Take now the case of magnesium. $Mg^{\cdot\cdot}$ is the only simple divalent ion which can be expected to act on the heart simply quâ divalent ion. As we have shown, $Ca^{\cdot\cdot}$, $Sr^{\cdot\cdot}$, and $Ba^{\cdot\cdot}$ enter probably into special chemical relation with some constituent of the tissue, while the other metals which give divalent ions (such as beryllium, zinc, cadmium, etc.) form solutions which are hydrolyzed.*

It is generally stated that an emulsoid colloid is very insensitive to salts. This is not true, at any rate in the case of some typical emulsoids, when simple trivalent ions are considered. Quite small concentrations of the rare earth solutions can produce large effects on colloidal materials which present all the other characters of emulsoids. Many experiments on a variety of colloidal solutions lead me to the conclusion that a fairer statement of the characteristic relations between emulsoid colloids and electrolytes would be this: that as compared with the suspensoids there is a very great difference in the relative concentrations of simple di- and tri-valent ions needed to produce the same effect. While for suspensoids the ratio of the activities of di- to tri-valent ions is taken ordinarily as of the order of 3 to 100, for emulsoids it is rather of the order of 1 to 10,000. It is certain that these ratios vary widely with different colloids, and that from a more precise study of these ratios than has at present been undertaken much more will be learnt about the colloids themselves, but the broad distinction appears to hold.

On the artificial scheme of membranes, then, magnesium produces effects tending in the same direction as those produced by the simple trivalent ions and by the hydrogen ion, but is enormously less potent than these.

Precisely the same is true of the action of $Mg^{\cdot\cdot}$ on the heart.

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* Incidentally it should be noted that the effect of hydrolysis, as regards the activity of the solution on the heart and on colloids such as gelatine, is precisely opposite in the case of these solutions of divalent ions from that described for trivalent ions. For the H ions, though less powerful than the equivalent concentration of simple trivalent ions, are much more powerful than the equivalent concentration of divalent ions in these relations. Consequently a solution of beryllium, which is hydrolyzed, affects the heart, and colloid systems of the class sensitive to $H^{\cdot}$, much more powerfully than the non-hydrolyzed solutions of magnesium.

In the ray heart, for instance, a concentration of ·000001 M to ·00001 M of $Ce^{\cdot\cdot\cdot}$ or $Nd^{\cdot\cdot\cdot}$ is sufficient to cause prompt arrest in diastole. The same effect can be produced by $Mg^{\cdot\cdot}$, but the concentration needed is about ·02 M. If our explanation of the action of magnesium on the heart is true, it should of course be found that the dose of Mg needed to arrest the heart depends greatly on the P^{+}_{H} of the solution in which it is applied. An increase in the numerical value of the P^{+}_{H} should tend to counterbalance the effect of magnesium. This is abundantly confirmed by experiment. For example: a ray heart was brought to rest by raising the concentration of $Mg^{\cdot\cdot}$ in the solution, perfusing it to ·025 M. The diastolic arrest occurred after two or three contractions. When the heart had remained completely at rest for a minute with this solution running through, without changing the concentration of $Mg^{\cdot\cdot}$ the P^{+}_{H} of the solution was raised from about 6·5 to 9. Within a few seconds the heart started beating, and continued to beat in this solution as strongly and regularly as in the original solution which contained no excess of $Mg^{\cdot\cdot}$.

Consideration of the relations of colloidal materials to simple and complex trivalent kations enables us to make certain inferences as to the nature of these colloidal substances from which we can predict their relations to certain other ions. Applying this principle to the heart, we arrive at conclusions as to the nature of the colloidal membranes in its structure from which we can predict the action of magnesium upon the heart-beat.

Finally, I wish to indicate certain directions in which experiments of this kind may assist in the development of a scientific comparative physiology.

Two instances which I have encountered in the course of work at the Plymouth Laboratory this summer may serve as illustrations.*

The facts already stated about the general similarity in the relations of the heart muscle of widely different species to Ca, Sr, and Ba encourage the belief that the general character of the mechanism is the same in these varieties of heart muscle. Can we find differences in the relations of the membranes to "charging" electrolytes? What kind of differences are to be looked for?

A study of the properties of colloids by a variety of methods leads to the following conclusions with respect to the part played by the nature of the colloid itself in determining its relations to electrolytes.

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* I am much indebted to Miss Dale, of Newnham College, for her skilful assistance in this work.

(1) Different surfaces in the same solution may take on different electrical charges.

(2) Different surfaces possessing the same charge in some particular solution may require different concentrations of the same electrolyte to produce equal changes in their charges.

The physiological expression of a difference in the heart membranes of the kind indicated in the first of these conclusions would be of this type: that one kind of heart should behave in a neutral solution as another would behave in an acid or in an alkaline solution, other conditions being equal.

The heart of the mollusc Pecten maximus differs from all the vertebrate hearts studied in this way. On perfusing it with "neutral saline" it stops instantly in systole. It will beat, however, if we alter the P^{+}_{H} of the solution in the direction of slightly increased acidity; if the change is carried a little further, diastolic arrest—the characteristic acid effect—is then produced. Now the P^{+}_{H} of the solution which perfuses the heart of the living Pecten—the blood of the animal—is about 6·5 to 7, that is to say, very slightly on the *alkaline* side of our "neutral saline." ? How then can the heart beat in such a solution? The answer is simple. The blood of Pecten contains a large concentration of magnesium. The divalent $Mg^{\cdot\cdot}$ is present in sufficient concentration to bring the charge of the membranes to the value required for their proper differential permeability.

The assertion that the blood of Pecten is practically the same as sea-water overlooks one important fact about it. Though its osmotic pressure and concentrations of Na, Mg, K, Ca, etc. are closely the same as in sea-water, there is a distinct difference in the P^{+}_{H} of the two fluids. The P^{+}_{H} of sea-water varies from about 7·9 to 8·3, while that of the Pecten blood is rather below 7. The difference may be demonstrated by adding a drop of a solution of rosolic acid to a little sea-water and to a similar quantity of the colourless blood of Pecten. The colour given by the former is bright pink, that of the latter yellow or yellowish pink.

Thus we find that sea-water, despite its high concentration of magnesium, on perfusion instantly stops the Pecten heart in systole.

But if by the addition of a little dilute hydrochloric acid we change the P_{H}^{+} of the sea-water to the same value as that found for the blood of Pecten (about 1·5 cc. of ·1 M HCl in 100 cc. of sea-water), we have at once a solution which sustains the beat of the heart admirably. A solution of the same composition as this but without magnesium causes the heart to stop in systole. Further, as is predicted theoretically, it is possible to replace the Mg by a very small concentration of a simple trivalent ion. Thus the Pecten heart which has stopped beating in "neutral saline" can be made to beat again and be kept beating for a considerable time by the addition to the solution of a concentration of about ·00003 M of $Ce^{\cdot\cdot\cdot}$ or $Nd^{\cdot\cdot\cdot}$. Here we have one trivalent ion doing the work of some 40,000 divalent ions, and it is therefore not surprising that the solution with rare earth does not, as a rule, keep the heart going so regularly as the solution with magnesium. Higher concentrations of the simple trivalent ions (e.g. ·0001 M) stop the Pecten heart in diastole exactly in the same way as a too acid solution.

We may express the difference between the heart of Pecten and the hearts of the vertebrates which have been studied, by saying that the membranes have different iso-electric points. This kind of difference is most probably related to a difference in the chemical composition of the membranes; it being a well-established fact that different protein substances found in the animal kingdom do show differences of this kind, according to the predominance of the "acidic" or "basic" amino-acids included in their composition.

It is by no means a new suggestion that the differences between different species are at root differences in the chemical composition of their tissues; but as far as I am aware it has not before been pointed out by what mechanism such differences can affect the physiological behaviour of the living heart.

The second conclusion formulated above as to the relations between different surfaces and the same electrolytes finds biological application in the differentiation of more closely allied species.

The hearts of the elasmobranchs Raia and Scyllium are kept beating satisfactorily for many hours by perfusion with the same "neutral" solution containing sodium, potassium, calcium, and magnesium chlorides and urea, the solution being thoroughly aerated and of P_{H}^{+} about 6·5. The concentration of Mg in the solution generally used was ·005 M. Removal of the Mg from the solution only causes the beats to get rather faster. Increase of the concentration of magnesium causes slowing of the heart-beats, and if carried far enough, stoppage. Qualitatively these phenomena are alike in the hearts of the ray and of the dogfish. But studied quantitatively the ray heart is found to be much more sensitive to Mg than is the dogfish heart. Thus taking the mean of a number of observations on ray* hearts, the concentration needed to give a 50 per cent reduction in the rate of beat (calling the rate in the solution with ·005 M Mg = 100) was only ·009 M. For Scyllium it was ·05 M. To stop the ray heart the concentration of $Mg^{\cdot\cdot}$ needed was about ·02 M, while to stop the heart of Scyllium a concentration usually greater than ·1 M was required.

A corresponding difference is found in the sensitiveness of these hearts to the simple trivalent ions. Thus ·00001 M $Ce^{\cdot\cdot\cdot}$ readily stops the heart of Raia, while a concentration approaching ten times this magnitude is needed to produce the same effect on the heart of Scyllium.

In these respects the heart of the angel fish, *Rhina squatina*, was found to resemble that of the dogfish rather than that of the ray. The curve representing its behaviour in the presence of various concentrations of Mg lies between that plotted for Raia and that for Scyllium, but much nearer the latter than the former. This is interesting, as in the ordinary morphological classification Rhina is placed between the Scylliidae and the Raiidae. It is said that Rhina resembles rays rather than dogfish in its general habits, yet it is possible that the character indicated by these experiments represents something deeper seated than the details of the responses given by the central nervous system.

It is at any rate conceivable that by the extension of work along these lines we may learn to express genetic affinity in physico-chemical terms.

One further point. It will be recollected that the behaviour of a membrane depends not only on its original composition and on the nature of the solution immediately surrounding it, but also to some extent on its previous history. I have found that the blood plasma of Scyllium and of Rhina is of P_{H^+} numerically slightly higher than the plasma of *Raia* (*clavata* or *blanda*). It is possible that the difference in sensitiveness of the hearts of these animals to the agencies we have named is to be explained in part by the fact that their membranes have been bathed for years before the experiment in solutions of slightly different $P_H +$.

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* Two species, *R. clavata* and *R. blanda*, were used in these experiments. No difference could be detected in the behaviour of the hearts of these two species towards electrolytes. Using rays of very different sizes no constant differences were found between the large and the small specimens.

There are striking differences in the relations of the hearts of different species of animals to hydrogen ion concentration and to polyvalent ions: these correspond exactly to differences found in the effects of these ions on the ionic permeability of different colloidal materials. A mechanism is thus suggested which explains how differences in the chemical constitution of a tissue component may cause differences in the physiological behaviour of the living tissue.

I venture to hope that these fragmentary remarks will make it apparent that a field of research lies open here, containing treasure not alone for the physiologist who desires to elucidate the mechanisms by which vital processes are wrought in the individual, but also for the zoologist, who in looking for clues of genetic affinities has learnt the limitations of pure morphology and the truth of the axiom of physiology that by studying what a cell can do we shall best learn what it is.

For the furtherance of the science of Comparative Physiology the co-operation of morphologists and physiologists with physical, organic, analytical, and colloid chemists is necessary. This country is not lacking in any of these. The study of the science can be carried on best where the greatest variety of animals, living and in good condition, can be provided. This condition is most perfectly fulfilled at a marine station.

At Plymouth the fauna is rich, and the facilities provided in the Laboratory for keeping animals in condition for physiological experiment are admirable. It is earnestly to be wished that more workers in this country would interest themselves in a branch of zoology and of physiology pregnant with interest for both sciences, and that their efforts might secure for the Plymouth Laboratory permanent accommodation and equipment for physiological work, on a scale approaching that provided by marine stations in other countries.

In conclusion, I would express my warmest thanks to the Director and Staff of the Laboratory of the Marine Biological Association at Plymouth for much valuable assistance and advice.*

September, 1911.

* I am indebted to Professor Stanley Gardiner for the use of a University Table at the Plymouth Laboratory during July, August, and part of September.

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Types of Crustacean Blood Coagulation.

By

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Having been engaged at intervals during the last few years in studying from a physiological point of view the coagulation of crustacean blood —Tait (08), (10, A and B), (11)—and finding more variation in this regard in different crustacea than has hitherto been recognized, it suggested itself to me to inquire if the observed differences are correlated with any special physiological peculiarities, and, further, if they depend in marked degree on phylogenetic relationship. It is not a simple matter to settle either of these questions, and I make no pretence to have done so. At the same time, I have thought it worth while to put my observations on record, in the hope that the matter may thus sooner arrive at a satisfactory settlement.

The literature of the subject and details regarding the technique of examination of the blood and other particulars I hope shortly to publish elsewhere. Suffice it here to state that at least three distinct modes of blood coagulation may be recognized in crustacea :—

A. Simple agglutination of the blood corpuscles without any subsequent jellying of the blood plasma. (This is probably the most primitive and essential device both in invertebrates and vertebrates for procuring arrest of hæmorrhage from a wound.)

B. Agglutination of the blood corpuscles with subsequent general jellying of the plasma.

C. Jellying of the plasma in two successive stages, the preliminary cell-agglutination being relatively insignificant. The first plasma coagulation consists of localized (primitively globular) clots, which occur around or in immediate relation to special blood corpuscles, originally discovered by Hardy (92), and by him named "explosive corpuscles." At a later stage a second jellying process occurs, which this time involves the whole of the remaining plasma.

Although it is not my intention to discuss in detail the basis on which crustacean coagulation is separated into these three types, it would be a mistake to convey the impression that a hard and fast line of separation can be drawn between them. The classification is arrived at by examining the blood always under the same conditions—that is to say, *entirely removed from the vessels and placed either in a dish or on a glass slide.* These are, in fact, the conditions under which observations on coagulation are generally made. The classification here given represents a more extended knowledge than that hitherto in vogue—originally due to Heim (92)—which recognizes two groups, viz. A and B above.

COAGULATION C.

It will be convenient to begin with coagulation C, which is associated with the presence of explosive cells, and which from its complexity must be regarded as a somewhat specialized form of coagulation.

This form seems to be specially frequent in Isopoda. I have found it in *Conilera cylindracea,* in *Idotea baltica* and *emarginata,* in *Ligia oceanica,* in *Oniscus,* and in one or more species of *Porcellio,* i.e. in individual members of three sub-orders out of six.* On the other hand, I have failed to find it in *Gnathia maxillaris,* in *Dynamene rubra,* in *Sphaeroma serratum,*† and in *Jaera marina,* though possibly owing to the fact that the amount of blood obtained from these relatively small specimens was too meagre to allow of a satisfactory examination.

Among Amphipoda the occurrence of coagulation C seems to be much less frequent. It is not present in *Gammarus marinus,* in *Gammarus pulex,* in *Orchestia littorea,* nor in certain specimens of *Caprella* examined by me. On the other hand, I have recorded its presence in *Gammarus locusta*—Tait (10, B). This was not, however, under the conditions above specified—that is to say, in blood wholly removed from the animal and examined separately on glass, nor have I as yet observed it under these conditions.

As regards the Mysidacea coagulation C is absent in at least one species of *Mysis* (the only member of this order examined by me).

Crustacean blood coagulation has been chiefly studied in the

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* The zoological classification referred to in the present paper is that given by Calman in Part VII of Lankester's *Treatise on Zoology.*

† In the course of this work I found that *Sphaeroma serratum* (with black chromatophores) undergoes colour change in response to its background, like that undergone by *Idotea*—V. Bauer (05)—and by *Ligia*—Tait (10, C)—whereas *Oniscus* and *Conilera,* the latter possessed of orange and lemon-yellow chromatophores, do not.

Decapoda, and it is of especial interest to know if coagulation C occurs among them. Of this order I have examined *Pandalus montagui* and *P. brevirostris, Hippolyte varians* and *H. viridis, Palaemon serratus, Crangon vulgaris, Palinurus vulgaris, Homarus vulgaris, Astacus fluviatilis, Galathea squamifera* and *G. strigosa, Porcellana longicornis* and *P. platycheles, Eupagurus bernhardus* and *E. prideauxii, Ebalia tuberosa, Corystes cassivelaunus, Carcinus maenas, Portunus puber, P. marmoreus, P. arcuatus* and *P. depurator, Atelecyclus septemdentatus, Cancer pagurus, Xantho hydrophilus* and *X. incisus, Inachus dorynchus, Macropodia rostratus, Hyas coarctatus* and *Maia squinado;* and have found coagulation C only in two members of the list, viz. in Palinurus and in Astacus. It is thus an uncommon form of coagulation in the Decapoda, while it is doubtful if it occurs at all in the Brachyura.

The examples hitherto mentioned exhaust the crustacean forms in which I have looked for the presence of coagulation C. I shall now say a word or two regarding this form of coagulation in its physiological aspect.

The clotting associated with the presence of explosive cells is a sufficiently striking one. Thus the blood of Palinurus forms the stiffest jelly of any crustacean blood I have examined; Ligia blood also forms a specially firm coagulum; while the onset of coagulation is in all cases rapid. In the solidity of the jelly formed, coagulation C represents the most advanced form of coagulation to be met with in crustacea.

Assuming that the object of plasma coagulation is to provide an additional mechanism for stopping a wound (cell-agglutination being, as above indicated, the primary and most essential mechanism for this purpose) it would follow that, *ceteris paribus*, a hæmorrhage in an animal possessing explosive cells would cease sooner than a hæmorrhage in other crustacea. This being so, one would look in isopods, in Palinurus and in Astacus for some special cause necessitating the existence of an extraordinary mechanism for arrest of hæmorrhage.

One naturally thinks of the process of autotomy in this connection. The reflex surrender of damaged limbs is generally conceded to be a method of preventing undue loss of blood. Where the reflex is present in least degree one might expect on the whole to find the highest degree of coagulability of the blood, and *vice versa*.

Now isopods do not show autotomy. In Astacus the reflex is said to be present—Huxley (80)—though in my own experience and in that of others, e.g. Fredericq (83), it is not readily demonstrable even in specimens presumably fit and healthy. In isopods and in Astacus, therefore, the association is what one would *a priori* expect. In

Palinurus, however, whose blood forms such a stiff coagulum, the power of autotomy is present in very marked degree. Thus the form of coagulation associated with the presence of explosive cells does not imply absence or defective power of autotomy.

If, again, we direct our attention to the crustacea that possess incoagulable, or rather non-coagulating, blood-plasma (type A), we find the evidence equally contradictory. Thus in Maia and in Cancer, both of them forms with non-coagulating plasma, power of autotomy is marked. In the spider-crab, *Inachus dorynchus*, whose type of blood coagulation likewise falls under group A, the presence of autotomy is unusually difficult to demonstrate. It seems that no constant relationship exists between power of autotomy and any special form of blood coagulation.

The assumption with which we originally started, viz. that the property of coagulability in blood plasma exists or has been evolved for the sole purpose of arresting hæmorrhage, may however be unwarranted. All the microscopical observations made on the arrest of hæmorrhage from a vessel, whether in invertebrates or in vertebrates, including mammals, go to show that the opening is plugged chiefly by adhesion and agglutination of cells at the cut surface. The blood of a hæmophilic person forms a perfectly firm clot: in spite of the presence of the clot, however, blood continues to ooze for hours and even days from a wound. Again, we meet with coagulability in physiological fluids other than blood. Milk clots in the stomach: yet no one has suggested that this coagulation has a merely mechanical function. Considerations such as these warn us against drawing premature conclusions in regard to the purpose for which coagulability exists in the blood plasma. In circulating blood there are multitudinous chemical processes constantly going on, the nature of which is entirely hidden from us. Who can say that coagulability is not primarily concerned in some of these hidden processes?

As a matter of fact, when we compare the actual time taken for natural arrest of hæmorrhage from the terminal segment of one of the limbs of Maia and of Palinurus respectively, we find that, while the hæmorrhage is, to begin with, equally profuse in both cases, the Maia wound is closed as soon as the Palinurus wound. Maia blood is characterized by the absence of all plasma coagulation. Palinurus blood is highly coagulable. Until we have further knowledge as to the *raison d'être* of coagulability in blood plasma, attempts to correlate by *a priori* methods, different types of blood coagulation with special physiological conditions can be but shots in the dark.

I shall conclude this physiological discussion by referring shortly to two other conditions with which at one time I imagined coagulation C might possibly be correlated. Having discovered coagulation C in isopods long before I found it in any decapod, I looked for other physiological peculiarities characteristic of isopods as opposed to decapods. An obvious one is the peculiar method of moulting observable in isopods. A moulting isopod throws off first the covering of the abdomen along with that of the posterior three thoracic segments. At a later date the covering of the head and anterior four thoracic segments is got rid of.* In decapods the moulting process does not occur in two stages. Once again, a fact to which attention has not been called, so far as I know, isopods do not turn red on boiling as so many decapods do. The discovery, however, of coagulation C in decapods, which moult in a different fashion and turn red on boiling, disposed of any possibility of establishing a correlation with these two phenomena.

COAGULATIONS A AND B.

Before discussing coagulation C in its zoological bearing, it may be well to make some statements regarding the distribution of the other two forms of coagulation, viz. types A and B. To determine the existence of one or other of these two types a greater quantity of blood is necessary than when one looks merely for the presence of coagulation C. Partly for this reason my data are somewhat meagre, and refer only to fairly large crustacea of the order Decapoda. The results agree to some extent with those of Heim (92).

Coagulation A is present in *Cancer pagurus, Maia squinado, Inachus dorynchus, Macropodia rostratus,* and *Hyas coarctatus.*

Coagulation B is present in *Carcinus maenas, Palaemon serratus, Portunus puber*, and *Homarus vulgaris.*

The last four animals are arranged in order according to the extent and firmness of the plasma jelly that forms in their blood after withdrawal. In *Carcinus maenas* the bulk of the plasma remains indefinitely fluid; in Palaemon the jelly, which is soft, involves almost all the plasma; in Portunus there is a complete and fairly firm jelly; while the plasma of Homarus clots with exceptional firmness.

I should like to make two comments on these results. In the first place, there is a complete series of gradation of plasma coagulation to be observed in group B. The amount of plasma jelly formed in the blood of *Carcinus maenas* is so slight that we might almost include the animal under group A. This indicates a difficulty in drawing a sharp line of distinction between group A and group B. In the second place, the coagulation observable in Homarus blood (at the other end of the series) approaches, in regard to its mere firmness apart from the mechanism involved in its production, most nearly to the coagulation seen in the blood of Palinurus or of Ligia.

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* I do not know that anyone has called attention to the fact that the separation between the two cast-off portions of the integument occurs just at the anterior limit of the heart, as determined by the researches of Delage (81).

ZOOLOGICAL SIGNIFICANCE.

From what has been said it will be apparent that the various categories into which crustacea fall according to the form of blood coagulation observed in them do not coincide in any striking fashion with the subdivisions into which they are grouped by zoologists. Within the order Decapoda alone we meet with all three types of coagulation. When, within this order, we consider the animals characterized by one given type of coagulation, we find that they are not necessarily close allies from a morphological point of view. Thus Palaemon, Homarus, and Portunus, similar as regards blood coagulation, represent extremes of decapod structure; from a blood coagulation point of view, again, we should group Astacus with Palinurus rather than with Homarus, an arrangement that would appeal to no morphologist; and so on.

On the other hand, there are indications that one and the same type of blood coagulation may sometimes keep constant in the members of a given zoological group. The prevalence in so many isopods of coagulation C, a type rare in decapods, is one example. Another is the apparent universality of coagulation A among the Maiadae. Then, again, among the decapods coagulation C is confined to the macrurous Reptantia.

The question, so far as it concerns the zoologist, now comes to be: Do the facts above related afford any justification for utilizing the physiological method of inquiry in the task of deciding upon the inter-relationships of crustacea? It seems that while a valid case for the actual applicability of this method has not been established, a case has at least been established for the desirability of further research along this line. As a further justification for this standpoint, I would quote the following sentence from Calman (09):—

> "The classification of the Decapoda is a very difficult problem, and none of the schemes hitherto proposed can be regarded as entirely satisfactory. The traditional classification of the group into the long-tailed Macrura and short-tailed Brachyura was established by Latreille

in 1806; but the difficulty of defining these groups is shown by the varying limits which have been assigned to the intermediate group of Anomura established by Milne-Edwards in 1834. Boas, in 1880, was the first to make a radical departure from this system. He pointed out that the Brachyura and Anomura were only single branches of the Decapod stock, and by no means equal in systematic value to the Macrura, which included several other branches not more closely connected with each other. In other words, just as in the classification of the Malacostraca as a whole, so within the Order Decapoda, the retention of the primitive 'caridoid facies' does not necessarily imply close affinity between the groups exhibiting it."

Again, referring to the Amphipoda, which were ranked by Leach along with the Isopoda in his group Edriophthalmata, he says (p. 239): "It seems very likely that their affinity to the Isopoda is not so close as has been supposed."

These statements are quite in accordance with the grouping that one would adopt from considerations of blood coagulation.

PHYSIOLOGICAL EVOLUTION.

Lastly, and this concerns principally the physiologist, we have in Crustacea an exceptionally appropriate assemblage of types in which to study the evolution of blood coagulation. In the blood or body-fluid of all invertebrates apart from arthropods, the only form of "blood coagulation" that occurs is an agglutination of the corpuscles—Cuénot (91), see also Geddes (80); there is no jellying of the plasma. In arthropods alone among invertebrates we meet with a true jellying or solidification of "fibrinogen" normally present in solution in the plasma. Now, in the class Crustacea, and even within the order Decapoda, we find some animals whose blood does not jelly, others in which the jellying process is present but insignificant, and others again in which it is very conspicuous. In this group of animals, therefore, we have a readily available series of types showing every gradation of evolution from complete absence of jelly (e.g. the spider-crabs) to the occurrence of very firm jelly-coagulation (e.g. the lobster and the rock-lobster).

Further, in the same class of animals we find that the jellying process, when present in what is possibly its most developed state, is associated with the presence of corpuscles having special physiological attributes. Assuming that the functional peculiarities of these cells represent a high degree of selective adaptation, we have to inquire by what steps the specialization has been brought about. The physiological features in question cannot be supposed to have sprung suddenly into existence in a few special animals. The explosive property and the jelly-producing property must be present in various stages of development in the blood-cells of different Crustacea. Crustacean blood-cells offer excellent material for the study of functional evolution.

Generally speaking, such studies have been much neglected in the past. Keith Lucas in two notable communications (09, A, B) has recently sketched the lines on which such investigation should proceed, and indicated the general bearing of the results that may be expected thus to accrue. I hope shortly to adduce some facts related to the coagulation of crustacean blood, which further illustrate this question of functional evolution.

A considerable portion of the work recorded in this communication was done during the occupancy of a table (granted by the British Association and by London University) in the Marine Laboratory, Plymouth. The expenses of that portion of the research done in Edinburgh were defrayed by the Carnegie Trust. I have to record my thanks to Dr. Allen, the Director of the Plymouth Laboratory, and his assistant, Mr. Orton, for help in the determination of species.

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The Amphipoda collected by the "Huxley" from the North Side of the Bay of Biscay in August, 1906.

By

E. W. Sexton.

WITH PLATE III.

THE Amphipoda dealt with in this paper were collected in August, 1906, by Dr. Allen, to whom I am indebted for the opportunity of examining them.

The collection contained thirty-five species (belonging to twenty families), of which one only, *Tryphosites alleni*, is new to science. Five others, *Stenothoe richardi*, *Syrrhoites walkeri*, *Syrrhoe affinis*, *Eusirus biscayensis*, and *Rhachotropis rostrata*, are recorded for the first time since their original discovery. The geographical range of five species has been considerably extended, viz. *Syrrhoe affinis*, *Tmetonyx similis*, *Sympleustes glaber*, *Epimeria parasitica*, and *Laetmatophilus tuberculatus*; the four last forms have not been hitherto recorded with certainty south of Norway.

Several of the genera have been discussed separately in four papers which I have published elsewhere [**34–37**].

The classification followed is that of Stebbing in his classical monograph on the Amphipoda in *Das Tierreich*. Previous records of the capture of any species in the Bay of Biscay are given below the account of the species.

The measurements in all cases, unless otherwise stated, are taken from the tip of the rostrum to the tip of the telson.

TRIBE GAMMARIDEA.

FAM. LYSIANASSIDAE.

GEN. Trischizostoma, Boeck.

Trischizostoma nicæense (Costa).

STATION XII. One specimen, an ovigerous female, measuring 23 mm. For synonymy and description, see Sexton (**34**).

Recorded once before from the Bay of Biscay by Chevreux as *Guerinella nicœensis* (**15**).

GEN. **Ichnopus**, A. Costa.

Ichnopus spinicornis, Boeck.

(Stebbing, *Das. Tierr.*, p. 52.)

STATION X. Six specimens, all females, the largest measuring 13 mm., the others small, averaging 5·5–6 mm. in length.

This species has been recorded before from the Bay of Biscay, trawled twice by the *Hirondelle* (Chevreux (**14**), p. 15), and once by the *Britannia* (Walker, (**46**), p. 159).

GEN. **Tmetonyx**, Stebbing.

Tmetonyx similis, G. O. Sars.

STATION II. One specimen, an ovigerous female, measuring 18 mm.

This specimen is a very large full-grown female, which has apparently developed the secondary sexual characters of the male. Tattersall has recorded a similar instance in his recent paper on Schizopoda (*Fisheries, Ireland, Sci. Invest.*, 1910, II [1911], p. 16), in which a full-grown ovigerous female had assumed the rostrum characteristic of the adult male.

The *Huxley* specimen agrees in every particular with Sars's description and figures (**30**), p. 93, pl. 33, with the exception of the antennae. Sars's description of the flagella is as follows: In the superior antenna "flagellum more than twice the length of the peduncle, and composed of about twenty articulations, the first of which is rather large, about equal in length to the four succeeding ones combined; accessory appendage scarcely attaining one-third of the length of the flagellum and six articulate. Inferior antennae but little longer than the superior, flagellum composed of about twenty-four articulations." In the specimen examined the first joint of the *primary flagellum* equalled in length the six following joints taken together; 19-jointed; *accessory flagellum* 7-jointed. The inferior antenna was twice the length of the superior; flagellum composed of 42 joints. Both pairs of antennae were calceoliferous, one calceolus on each joint, from the 5th–16th in the superior; and in the inferior from the 3rd–24th, then on alternate joints to the 30th. The calceoli do not form a continuous row, but alternate in the same way as those of the *Tryphosa antennipotens* figured by Stebbing in his *Challenger* Report, pl. 6.

This is the first record of the species from the Bay of Biscay.

GEN. **Tryphosites**, G. O. Sars.

Tryphosites alleni, Sexton.

STATION XII. Two specimens, ovigerous females, measuring 10 mm. in length.

For description and figures see (**37**).

FAM. **METOPIDAE.**

GEN. **Proboloides, Della Valle.**

Proboloides gregarius (G. O. Sars).

(Stebbing (**41**), p. 189.)

STATION XIII. One specimen, an ovigerous female, 5 mm. long.

First gnathopod. The palmar margin is sharply serrated, as well as the inner edge of the finger. The finger carries a small decurrent tooth subapically, two setules inset in the notch and four others at intervals along the margin. The 4th and 5th joints are furnished posteriorly with strong flat dentate bristles in addition to the feathered setae, three on the 4th joint and two on the 5th.

Recorded once before from the Bay of Biscay by Walker (**46**), p. 159.

FAM. **CRESSIDAE.**

GEN. **Cressa**, Boeck.

Cressa dubia (Bate).

(Stebbing (**41**), p. 191.)

STATION VII. Depth, $\frac{\cdot}{444}$ fathoms; one specimen, a male, 2 mm. long.

The previous records from the Bay of Biscay (Chevreux (**13**), p. 478, and (**10**) p. 121) are from quite shallow water, 6 m.

FAM. **STENOTHOIDAE.**

GEN. **Stenothoe**, Dana.

Stenothoe richardi, Chevreux.

(Stebbing (**41**), p. 194.)

STATION XIII. One specimen, a male, measuring 4·5 mm. in length; trawled in 412 fathoms.

The only other specimen known, also a male, 5 mm. long, was taken by the *Princesse Alice* (Chevreux (**12**), pp. 427, 432–5), in August, 1894, in this same region, to the south of *Huxley* Station. The method of capture was the same, the trawl; the depth recorded 1262–748 mètres.

FAM. **ACANTHONOTOZOMATIDAE.**

GEN. **Iphimedia,** Rathke.

Iphimedia obesa, Rathke.

(Stebbing (**41**), p. 214.)

STATION V. One specimen, nearly 12 mm. in length, several young remaining in the pouch.

Boeck (**4**), p. 246, erroneously describes the maxilliped-palp as 4-jointed, the 4th joint rudimentary, although in the figure (Pl. XVIII. fig. 11 h.) it is represented as 3-jointed. Sars gives the number of joints as three, "dactylus wholly wanting" (**30**), p. 377. The *Huxley* specimen agrees with Sars's figure, except that the apex of the 3rd joint is truncate, not rounded. The large sensory spines on this joint are each composed of a stout feathered shaft and a small endpiece, which is inserted in the cleft at the apex of the shaft.

Recorded by Chevreux (**13**), p. 479, and (**14**) p. 63; and by Walker (**46**), p. 159. Chevreux's records are from much shallower water, 10–50 mètres.

FAM. **TRONIDAE.**

GEN. **Syrrhoites,** G. O. Sars.

Syrrhoites walkeri, Bonnier.

(Stebbing (**41**), p. 281.)

STATION XII. One specimen, a large female, 9 mm. in length.

This is the first record of the species since its discovery by the *Caudan* Expedition in the Gulf of Gascony, 1895.

The *Huxley* specimen is larger and older than the female described by Bonnier (**6**), pp. 647–50, measuring 9 mm., as compared with the "un peu moins de 7 mm." of Bonnier's largest specimen. The greater age is shown by the greater number of joints in the flagella of the antennae, Bonnier's female having nine in the superior flagellum and seven in the inferior, while the *Huxley* specimen has eleven and nine respectively. The incubatory lamellae are fully developed, no eggs remaining in the pouch.

GEN. **Syrrhoe,** Goës.

Syrrhoe affinis, Chevreux.

1908. *S. affinis,* Chevreux (**16**), pp. 7–9, fig. 4.)

STATION IX. Two specimens, measuring 9·5 mm., ovigerous females, one with eggs nearly hatched.

The following notes may be found useful in supplementing the short account given by Chevreux:—

Body. Peraeon-segment 7, and pleon-segments 1–4 dorsally serrate as in *S. papyracea* Stebbing, to which it bears a strong resemblance. The number of the serrations differs in the different segments, and occasionally the number on one side of a segment differs from the number on the other side; each serration has a long fine setule inset. In peraeon-segment 7 the serrations number twenty on the right side of the prominent central tooth and eighteen on the left; they extend across the segment almost to the posterior angles, each of which is produced into a small tooth with a setule inset above. The 1st pleon-segment has twenty-five serrations, the middle one much the longest; postero-lateral angles acutely produced, as in the 2nd pleon-segment also. This latter has twenty-one serrations, the middle one again the longest; five sensory spines inset along the inferior margin of the epimera, which are much dilated anteriorly as well as posteriorly. There are eighteen dorsal serrations on the 3rd pleon-segment, the two middle ones, of unequal length, much longer than the others; the epimera are considerably dilated inferiorly, the hind margin with seventeen upturned serrations, each with a setule inset. The 4th pleon-segment has twenty-five of the serrations; while the 5th carries two or three similar serrations on either side, just above the insertion of the uropods.

Head. Strongly vaulted in front, equalling the first four peraeon-segments taken together, in length; rostrum depressed, reaching beyond the middle of the 1st joint of the antenna, sharp-edged, apex very acute; lateral corners not much produced, truncate.

Sideplate 1. Front margin lightly curved forward; front angle subacute, hind angle rounded; posterior margin produced proximally as in Sideplate 2; inferior margin dilated. Inferior margin of Sideplate 2 narrowed and rounded. In Sideplate 3 the truncate portion of the hind margin has a crenulate appearance owing to the insertion of four or five setules. Sideplate 5 not much produced anteriorly, expanded and rounded posteriorly. In Sideplate 6 the anterior portion is hardly developed at all; the posterior portion is greatly produced downwards with its inferior margin truncate, one serration at the posterior angle. Sideplate 7 also with one tooth posteriorly, as noted by Chevreux.

Antennae. Superior antenna. 1st joint of the peduncle thick, more than twice as broad as the succeeding joints, with a strongly upcurved apical tooth; 2nd joint nearly as long as the 1st; 3rd not quite three-quarters the length of the 2nd, all carrying ciliated hairs and setae. *Primary flagellum* 15-jointed, with a long sensory filament on alternate joints; 1st joint long, nearly equalling the 3rd joint of the peduncle in length; 2nd joint very short; 3rd joint half as long again as the 2nd; apical joint tipped with long setae and one ciliated hair. *Accessory flagellum* as long as the 1st and 2nd joints of the primary taken together.

Oral parts much as in *S. papyracea* Stebbing.

Upper Lip (Pl. III, fig. 1) partly carinate, distal margin truncate, corners rounded and edged with microscopic spinules.

Lower Lip, outer lobes large and rounded, covered with fine hairs, with two double-tipped sensory spines on the inner margin of each, near the apex, similar to those described by Stebbing in *S. papyracea; inner lobes* inflated, covered with fine hairs; *mandibular processes* widely divergent, and narrowed distally.

Mandibles (Pl. III, figs. 2 and 3). Right mandible, *cutting-plate* margin irregularly crenate, produced below into two large teeth, with one small one between them; *accessory plate* large, dentate, the three sharp teeth above separated from the two large rounded ones below by a transverse row of three minute sharp denticles, the uppermost tooth with a denticle at its base. In the figure the plates are laid back to show their structure, which, owing to their great curvature, it is impossible to see in the natural position. In the left mandible, the *cutting-plate* margin is crenate, produced below into two large rounded teeth; *accessory plate* with five rounded teeth, the lowest the largest. There are six spines in the right *spine-row*, two large ones covered with minute tubercles, and four slender flexible ones, feathered on both sides; eight in the left spine-row, three large and five slender; the 1st spine is falciform in both rows. *Molar* prominent, strongly denticulate, with a feathered seta inset posteriorly, the teeth on the posterior edge of the crown longer and sharper than those on the anterior portion, front edge sinuous.

Maxilla 1 very like *S. papyracea*. *Outer plate* truncate with eleven spines in two rows, seven long spines in one row, and four shorter in the other. In the row of long spines, the two innermost are finely plumose, the next three denticulate with from twelve to sixteen denticles plumose on the outer side near the tip, the two outermost spines with five and three larger denticles respectively. In the other row, the two inner spines are simple, the 3rd carries one large and two small denticles, and the 4th spine is very stout, curved, and simple. The *inner plate* is fringed with ten plumose setae, the apical two much shorter than the others. The *palp* is considerably longer than the outer plate, with both margins microscopically serrate; 1st joint short, with three setules on the outer margin; 2nd joint nearly three times as long as the 1st, apex truncate with four or five long spines inset, and about ten or eleven stiff setae set in pairs along the upper part of the inner margin; spines and setae very finely serrate.

Maxilla 2. *Inner plate* broader than the *outer;* the arrangement of the setae as in *S. papyracea.*

Maxillipeds (figs. 4 and 5). *Inner plate* reaching to the distal end of the 1st joint of the *palp;* upper margin truncate, furnished with four stout feathered spines, two curious bent spines directed inwards, and one feathered seta. The larger of these spines (fig. 4) is situated midway on the margin, the smaller one at the inner angle. Just below the smaller spine, the outer surface of the plate is deeply hollowed, and on the lower edge of this little hollow or groove stands a strong coupling spine (fig. 5). The upper half of the inner margin carries five long stout spines, set one behind the other, feathered on both sides for half their length like the spines on the upper margin. *Outer plates* reaching almost to the distal end of the 2nd joint of the palp, with a row of twenty-one strong flat spines, extending along the inner margin to the outer side of the rounded apex. These spines, downturned and apically dentate, increase gradually in length to the eighteenth, the remaining and outermost three are setiform. On the outer surface five or six pairs of setae are inset submarginally, and nearly the whole of the surface is covered with a furry armature of microscopic spinules. The 2nd joint of the *palp* is expanded on the inner side and fringed with long setae, with the fur-like spinose armature distally. The 3rd joint is much expanded on both sides, the finger thus appearing to be set in the middle of the distal margin; the whole joint is fringed with long setae, and carries a graduated row of cleft-tipped spines on the distal outer angle. The nail is more than half the length of the finger, with one setule above and two below.

Gnathopod 1 (Pl. III, figs. 6 and 7), 2nd joint long, lightly curved, carrying six to eight extremely long and delicate plumose setae posteriorly. These setae are sparsely plumose, the feathering being very long and fine; similar setae are found on the basal joints of Gnathopod 2, and peraeopods 1 and 2. The 3rd joint has one of these setae at the distal angle. 5th joint with the anterior margin fully twice as long as the anterior margin of the 6th; posteriorly it is a little expanded, covered with the fur-like spinose armature, and furnished with several densely crowded rows of spines on the margin; one row directed forward of small coarsely dentate spines, one row of small spines, another row of medium-sized, and a row of long cleft-tipped ones similar to the one figured (fig. 6). There appears to be another row beyond this of the medium-sized, and in addition three long fine, thread-like setae are found near the distal end, the longest being nearest to the hand and much exceeding it in length. The hand widens a little distally, hind margin pectinate; palm slightly oblique, fringed with long setae, and carrying at the palmar angle, besides the very large palmar spine, a group of five long spines, the apical flagella of which are of great length. The finger is a little longer than the palm, and crosses the palmar spine. For the construction of finger and spine, see fig. 7.

Gnathopod 2, 5th joint very slender, considerably more than twice as long as the 6th, furnished on the distal posterior margin with dense rows of setae. The setae appear to be arranged in groups set closely together along the margin, each group containing four graduated setae. The hand widens distally; it resembles that of Gnathopod 1 in the construction of the finger and palmar spine and in the arrangement of the long setae on the palm. The branchial vesicles are large, as long as the basal joint; incubatory lamellae large and wide, exceeding the basal joint in length.

Peraeopods 1 and 2, practically subequal in length; branchial vesicles large, incubatory lamellae long and narrow. 2nd joint very long and slender, with long plumose setae on both sides; 4th, 5th, and 6th joints subequal, fringed posteriorly with long fine setae; 6th joint with a stout spine and a dense fringe of these setae distally, almost concealing the finger, and exceeding it in length. The finger, as in all the peraeopods, has a long nail, both finger and nail pectinate along the outer curve; with two setules inset close to the nail, and one long plumose seta proximally on the outer margin. In peraeopod 2 the 5th and 6th joints have the anterior margin strongly pectinate.

Peraeopod 3, 2nd joint almost circular, one setiform spine and five short stout ones on the lower part of the anterior margin, nine deep serrations posteriorly; 4th, 5th, and 6th joints increase rapidly in length and decrease in thickness, all furnished with long sensory spines some of which are remarkable for the extraordinary length of their apical filaments. Another variety of spine peculiar to this peraeopod is to be found on the posterior margins of the 5th and 6th joints, eight on the 5th and seven on the 6th, each inset with a small long-filamented spine; the shaft is laminar, and the apex of the spine is produced to nearly the length of the apical filament (Plate III, fig. 8). The branchial vesicle and incubatory lamella are small, the hairs on the latter very long.

Peraeopod 4, 2nd joint large, rounded, more produced posteriorly than in Peraeopod 3; two setiform and six short stout spines anteriorly, ten serrations posteriorly. 5th joint half as long again as the 4th; 6th much longer than the 5th; finger not quite one-third the length of the 6th. The spines on the 4th joint are the longest, those of the 6th the shortest and most numerous; the apical filaments of all the spines are very long, but do not reach the remarkable length of those of the 3rd peraeopod.

Peraeopod 5, as Chevreux describes it; 2nd joint longer than broad, six setiform and six short spines anteriorly, thirteen serrations posteriorly. The setae as in Peraeopod 4.

Pleopods. The rami in all three pleopods are about twice as long as the peduncles; inner ramus with seventeen joints, outer ramus with eighteen; five cleft spines on the inner ramus. The coupling-spines are set in a little hollow with two long ciliated hairs; apices recurved; the upper spine has two large recurved teeth on one side, five small ones on the other; lower spine with three large and six small.

Uropod 1. Peduncle considerably longer than the outer ramus; it carries a row of seven long spines on the inner margin, six on the outer margin, the distal portion of which is produced in a long curved process reaching more than half-way down over the outer ramus. Outer ramus with three short spines on the margin, one large strong spine and two small inset at the apex. The inner rami are both broken but are evidently longer and broader than the outer. *Uropod* 2, outer ramus twice as long as the peduncle, inner ramus nearly four times as long. The peduncle carries two long stout spines at the outer angle. Outer ramus narrow, outer margin with three long sensory spines, inner margin with ten or eleven short stout simple spines; one broad stout spine and two small ones at the apex. Inner ramus broad and laminar; apex acutely produced: inner margin edged with a thick row of about thirty short stout simple spines; outer margin with sixteen long sensory spines inset at regular intervals. *Uropod* 3, badly mutilated in both specimens. Inner ramus two and a-half times longer than the peduncle; it appears to have small spines on the outer margin, and plumose setae proximally on the inner margin; both rami broad and laminar.

Telson. In the *Huxley* specimens the cleft is longer than Chevreux figures it. A pair of long ciliated hairs are inset on either side of the cleft near the margin, and several small flat spines are scattered over the surface proximally; the apices each with a setule in the fork.

Distribution. Taken by the *Princesse Alice*, 10 July, 1901, 33° 59′ 30″ N.; 8° 12′ 45″ W.; trawl; 851 mètres; 2 females, 7 mm. long. Chevreux (**16**).

Taken by the *Huxley*, 25 August, 1906; 48° 7′ N.; 8° 13′ W.; Agassiz trawl; 240 fathoms; bottom deposit, fine sand.

FAM. **CALLIOPIIDAE.**

GEN. **Apherusa,** A. O. Walker.

Apherusa bispinosa (Sp. Bate).

(Stebbing (**41**), p. 305.)

STATION IV. 109 fms.; 44 specimens; 30 of these were ovigerous females, 6·5-3·75 mm. in length.

STATION X. 146 fms.; 3 specimens, 1 male and 2 females, the larger of which measured 7 mm.

These captures are interesting as being the first authenticated records of the occurrence of this species in the open sea far from land. The depth at Station X., 146 fathoms, is the greatest hitherto recorded. *A. bispinosa* is generally regarded as a purely littoral or sublittoral form, and is usually found living among the algae close inshore. Sars, however, mentions (**30**), p. 440, "another form or variety living in somewhat greater depths," agreeing in all essential details with the littoral form, but distinguished from it by the larger size, the comparatively larger and less pigmented eyes, and the lighter hue of the body. The *Huxley* specimens are of this latter type. They are more slender and more spinose than the shore form.

The 3rd joint of the palp of the *mandible* in full-grown specimens is subequal to the 2nd in length, not shorter, as given by Sars for the shore form.

The *antennae* are filiform and longer than in the shore animal; the joints of the flagella very attenuated. The flagellum of the superior antenna is furnished with two sensory filaments on each of the first four joints, and two on alternate joints to the 14th in the female and to the 20th in the large males. The inferior antennae in the female are a little longer than the body; half as long again in the male. Unfortunately all were broken; one female of 5 mm. length had the inferior antenna 5 mm. long, fifty-one joints in the flagellum; and a male 7 mm. long had sixty-three joints still remaining, the broken antenna measuring 7·5 mm.

The proportions of the joints of the *gnathopods* are as given by Sars, but the hand and finger differ (Pl. III, fig. 9). The hand is broader, as in *A. clevei* Sars, with the palm oblique and subequal to the hind margin in length; the palmar margin is microscopically serrulate, with the two specialized bristles characteristic of the family, inset on either side of the finger. The finger is much longer in proportion than in the littoral form with four serrations on the inner margin in Gnathopod 1, three in Gnathopod 2.

The postero-lateral corner in *pleon-segment* 1 is produced to a small acute recurved point, as mentioned by Sp. Bate (**3**), p. 250. In pleon-segment 3 the hind margin above the postero-lateral corner is divided into eight serrations in the large full-grown specimens, seven in the small but sexually mature animals, each serration with a setule inset; the upper tooth of the bidentate projection is very acutely produced.

All the margins of the *uropods* are microscopically pectinate, with the exception of the inner margin of the inner ramus of *Uropod* 3. The distal half of the margin of the *telson* is also pectinate; apex distinctly tridentate with two setules inset; two pairs of mobile sensory plumose hairs.

Previous records: By Chevreux as *Halirages bispinosus* (**9**), p. 304; as *A. bispinosa* (**14**), p. 70; and by Walker (**46**), pp. 158–9.

FAM. PLEUSTIDAE.

GEN. **Sympleustes**, Stebbing.

Three species of this genus were taken, two from deep water 412 fathoms; and one hitherto regarded as an Arctic or sub-Arctic form *S. glaber* from a much less depth, 75 fathoms.

Sympleustes latipes (M. Sars).

(Stebbing (**41**), p. 317.)

STATION XIII. Three specimens, immature, measuring respectively 7·5, 4·5, and 2·5 mm.

Taken once before in the Bay of Biscay by the *Caudan* Expedition (**6**), p. 645, in 1410 metres.

Sympleustes grandimanus (Chevreux).

STATION XIII. Five specimens, females, 3–7·5 mm. in length.

For synonymy and discussion of this species, see Sexton (**35**), pp. 857–64.

Sympleustes glaber (Boeck).

(Stebbing (**41**), p. 318.)

STATION II. One specimen, a small female with ova, 4·5 mm. in length.

This species has not been recorded before south of the Kattegat. The *accessory flagellum* of the superior antenna, as in other species of the genus, is quite rudimentary, 1-jointed tipped with two or three setae (cf. Sexton (**35**), pp. 853 and 859).

FAM. **PARAMPHITHOIDAE.**

GEN. **Epimeria**, A. Costa.

Epimeria parasitica, M. Sars.

(Stebbing (**41**), p. 321.)

STATION IX. Twenty specimens.
,, XII. Twenty-three specimens.

This species is here recorded for the first time with certainty out of Norway. It is there found living in a semi-parasitic state on the skin of *Holothuria tremula* (**31**), p. 131, and (**30**) p. 367; the *Huxley* specimens on the other hand were taken free swimming in considerable numbers, at two stations. They are larger than the Norwegian specimens, quite half of them measuring 13 mm. in length as compared with Sars's statement: "length of adult female scarcely exceeding 9 mm." They appear to live at greater depths than *E. cornigera*. The incubatory lamellae of the females were well developed, but no eggs were found in the pouches.

Epimeria cornigeria (Fabricius).

(Stebbing (**41**), p. 323.)

STATION II. Two specimens, 17·5 and 18 mm. respectively.
,, V. Sixty-three specimens, average length 20 mm; the largest measured 23·5 mm.; 11 were half-grown, and 5 small. No eggs remaining in the pouches.
,, IX. Two large specimens, mutilated.
,, XI. Three specimens, largest 17 mm.
,, XII. One specimen, 22 mm. in length.

Several previous records by Chevreux (**14**), p. 62, but only one or two specimens taken at a time.

FAM. **ATYLIDAE.**

GEN. **Nototropis**, A. Costa.

Nototropis vedlomensis (Bate and Westwood).

(Stebbing (**41**), p. 331.)

STATION IV. One specimen, a female, 8 mm. in length.

The method of capture was by swab and townet attached to the dredge working at the bottom, depth 109 fathoms. Chevreux's records are from shallow water; under the name of *Atylus vedlomensis* as fairly common on sandy bottoms in the Bay of Croisic, 4–10 m. (**9**), p. 304; and as *Paratylus vedlomensis* at Concarneau, 15–19 m. (**13**), p. 480.

FAM. **EUSIRIDAE.**

GEN. **Eusirus**, Kröyer.

Eusirus longipes, Boeck.

(Stebbing (**41**), p. 341.)

STATION IV. Three specimens, males, the largest 8 mm.

Previous records: Chevreux (**14**), pp. 65, 171, 172; and Walker (**46**), p. 160.

Eusirus biscayensis, Bonnier.

STATION XII. Seven specimens; 6 females, 12–13·5 mm. in length, and 1 male barely 13 mm. long, the first hitherto recorded.

This is the first record of the species since its discovery by the *Caudan* Expedition. The original description was taken from a mutilated specimen. I have, therefore, redescribed and figured certain of the anatomical details (**35**), pp. 865–9.

GEN. **Rhachotropis**, S. I. Smith.

Rhachotropis helleri (Boeck).

(Stebbing (**41**), p. 351; and Sexton (**35**), pp. 869–76.)

STATION XII. Twenty specimens; 1 male, 8·75 mm., and 19 females, 10–12·5 in length.

This species has been discussed and the fully developed animal figured in the above-mentioned paper.

Rhachotropis rostrata, Bonnier.

(Stebbing (**41**), p. 353; and Sexton (**35**), p. 869.

STATION XII. Four specimens, males, 9–10 mm. in length.

This is the first record of the species since its discovery by the *Caudan* Expedition.

FAM. **GAMMARIDAE.**

GEN. **Maera**, Leach.

Maera tenuimana (Bate).

(Stebbing (**41**), p. 436.)

STATION V. One specimen, a male, 9 mm. long.

Previous records: by Chevreux as *M. Batei* Norman and *M. multidentata* Bate (**9**), p. 307; and as *M. Batei* Norman (**14**), p. 83; and by Walker (**46**), p. 160.

FAM. **PHOTIDAE.**

GEN. **Leptocheirus**, Zaddach.

Leptocheirus pectinatus, Norman.

= **Leptocheirus dellavallei**, Stebbing.

(Sexton (**36**), pp. 576–585, Pl. XIX.)

STATION II. One specimen, an ovigerous female, measuring 4·5 mm.

For the discussion of this species and proofs of the identity of the two forms *pectinatus* and *dellavallei*, see the paper referred to above.

FAM. **JASSIDAE.**

GEN. **Jassa**, Leach.

[**Jassa falcata** (Montagu).

No specimens of this species were taken during the cruise, but it is necessary to include a note relating to it in order to explain my reasons for using the specific name *falcata*, in the discussion of *J. pusilla*, instead of *pulchella* as established by Stebbing (**41**), p. 654. The species is a difficult one owing to the different forms assumed by the male during development, this causing great confusion not only in the species itself, many of the stages having been described as distinct species, but also leading to further confusion with other species, *pusilla* in particular.

There would seem to be at least two well-marked forms of *falcata*. During immaturity it is absolutely impossible to distinguish between them, but as they grow they differentiate into either—a form with the flagella of the antennae swollen, some of the joints coalesced, the hand also swollen, and thumb broad; or a form with the antennae slender, joints distinct, hand and thumb slender. In both forms there appear to be *two* distinct kinds of adult males, besides the several markedly different stages during growth. The females are exactly alike, except that some have antennae like the first form, and others like the second. Whether these will prove to be seasonal variations, or whether they are really two distinct species, I have not as yet sufficient evidence to speak with certainty. Experiments in rearing them, commenced in 1909 in the Laboratory here, have only been successful to a certain point; some of the stages have moulted but the series is still far from complete.

For figures of the first form see Nebeski (**23**), and for the second Sars (**30**), pl. 212; for the females Spence Bate's *variegatus* (**3**), p. 439, belongs to the first, *pelagicus* (**3**), p. 447, to the second form.

Through Dr. Calman's kindness I was able last year to examine in the British Museum the type specimens of Montagu's *falcatus*, Leach's *pulchella*, and Spence Bate's *variegatus*.

The type specimen of the species was taken by Montagu more than a hundred years ago at Torcross on the Devonshire coast. It is marked 603 a, and is referred to in the old manuscript register under that number as having been taken at Torcross. In the "List of the Specimens of Crustacea in the collection of the British Museum," 1847, by Adam White, it is entered (p. 89) as "*Cerapus falcatus* a. Devon (Torcross). From the collection of Col. Montagu." The specimen bears a sufficient resemblance to Montagu's drawing (**22**) t. 5, f. 2, to suggest that it was the actual one from which the drawing was made. It measures 8 mm. from the tip of the rostrum to the tip of the telson, and is of the type referred to above as the second form. The flagellum of the superior antenna has eight or nine joints, the inferior five. The second sideplate is of the form characteristic of the species, the anterior margin only half the length of the posterior margin of the preceding sideplate. The finger of the second gnathopod has a rather prominent process developed on the inner margin; this process I have found of frequent occurrence in the larger males. The small spines which are found behind the thumb process on the hind margin of the hand are represented in Montagu's figure as another process. They are naturally much more prominent in the dried specimen than in spirit specimens, owing to the shrinkage.

There are seven specimens marked "*Podocerus pulchellus*, Devon," in the old manuscript register, and numbered 296 a—g, which appear to be Leach's types. These are exactly the same form as Montagu's. Two have lost both gnathopoda and antennae; of the others, one is a young male with the thumb half developed, and the remaining four are adult males, thumb well developed, process on inner margin of the finger small. The antennae of all were broken, excepting two superior antennae, which had about seven joints each.

The tube marked *Podocerus variegatus* in Spence Bate's collection, as Mr. Walker pointed out (**44**), p. 472, contains more than one species, several of the specimens belonging to *J. pusilla*. Among the *falcata* were two young males and two or three full-grown ovigerous females of the type referred to above as the "first form," and figured by Bate as *P. variegatus* (**3**), p. 439.]

Jassa pusilla, G. O. Sars.

(Stebbing (**41**), pp. 655 and 739.)

STATION VII. One specimen, a large ovigerous female, 5·5 mm. long.
„ XIII. Three specimens, 2 males, 5 and 5·5 mm. respectively, and 1 female, 4·75 mm.

The separation of this species from *J. falcata* (Mont.) is rendered difficult not only by their great similarity, but by the enormous range of variation found in *falcata*, which at a first glance suggests the possibility of *pusilla* being only a young stage of that species. Walker was inclined to consider them identical; he says (**45**), p. 314: "If it be admitted that Amphipoda may become sexually mature before they have attained their final moult, I think these species [*pusillus* and *Herdmani*] can hardly be maintained"; and again (**44**), p. 473: "I am disposed to consider *P. Herdmani* and *P. pusillus* (Sars) as examples of arrested development and mere varieties of *P. falcatus*."

Sars and Stebbing, on the other hand, consider them distinct species, but, as several of the characters given by them for distinguishing the one from the other are those subject to developmental modifications, I have thought well to discuss the different points in detail.

The two most useful and constant distinguishing features will be found in the second gnathopod, viz. the second sideplate and the hand. The inferior margin of this sideplate in *pusilla* forms a continuous line with the margins of the 1st and 3rd sideplates, its anterior margin being as long as the posterior margin of the 1st. In *falcata*, on the contrary, the anterior margin is much shorter than the posterior margin of the preceding sideplate, only half the length in full-grown specimens, giving a curious and characteristic appearance to the animal, as if the head and 1st peraeon-segment were divided from the rest of the body (the coloration adding to the effect, the head of the 1st segment and sideplates being invariably darkly pigmented, and the 2nd segment and sideplates light with a few patches of pigment). This character is found even in the young in the incubatory pouch, though with them the anterior portion of the sideplate is rounded, whereas in the full-grown animal it is angular (see figs. 10 and 11 for comparison).

With regard to the second distinguishing feature, the hand, the adult male of *pusilla* has the apex of the thumb bifid; in the adult male of *falcata* it is entire; and an examination of many thousands of specimens of this latter species shows that in it the characteristic bifid form of *pusilla* is never met with.

General aspect. The body is more compressed in *pusilla*, the sideplates longer in proportion, and the peraeopods longer and more slender than in *falcata*. The cuticle is thinner, and the coloration also differs, as Sars noted when first describing the species (**29**), p. 112. In *falcata* the pigment is in dark definite bands or patches composed of stellate markings or of dots thickly crowded together, retaining its colour even after years in alcohol. The distribution of colour can be plainly seen in Montagu's specimen even now after a century. In *pusilla*, on the other hand, the pigment shows only as diffused indefinite transverse bands along the posterior margins of the peraeon-segments, and occasionally on the pleon-segments as well; spirit specimens retain very little of the colour.

Size. The difference in size is given by Sars (**29**), p. 112, as a specific character, but, as Walker pointed out, it cannot be used as such, for though *pusilla* is always small, never exceeding 5–6 mm., and *falcata* attains a length of 10–12 mm., yet specimens of the latter, both male and female, have been found sexually mature at 4 mm.

Sideplates (Pl. III, figs. 10 and 11). The *proportions* of the sideplates are generally given as specific characters, but they cannot be relied on as such, varying as they do with the age of the animal. Stebbing gives the *falcata* (**41**), p. 654, "3rd and 4th in ♂ considerably deeper than 2nd and 5th"; and for *pusilla* ♂ "5th nearly as deep as 4th." The sideplates in this latter species are always wider and much deeper in proportion to the body than in *falcata;* Sideplate 2 is rounded anteriorly, considerably expanded inferiorly, and twice as wide as deep (fig. 11); the 3rd and 4th the deepest, as wide as deep; the 5th almost as long as the 4th. In *falcata* the relative proportions alter with each stage of development, the only constant feature being the short anterior margin of Sideplate 2. In the young in the marsupium 2·25 mm. long, the inferior margins of Sideplates 1–5 are on the same level; in specimens 5–6 mm. in length, the 3rd, 4th, and 5th are on the same level, the 1st and 2nd shorter; at 7 mm. length, the 5th is slightly shorter than the 4th; while in large specimens 9 mm. and upwards, the 1st, 2nd, and 5th are very noticeably shorter than the 3rd and 4th.

Antennae. Here again the proportions of the joints of the peduncles, and the number of joints in the flagella vary with the growth of the animal, and cannot be employed in specific distinction. The antennae in *pusilla* are much more slender, and the primary and accessory flagella much longer in proportion than in *falcata*. The joints of the primary flagellum are long and cylindrical, and the accessory flagellum is longer in proportion to the 1st joint of the primary than in the other species, equalling half the length of the 1st joint in the adult animal. The last joint of the peduncle of the inferior antenna is fringed with long setae. Of the *Huxley* specimens the two males each have five joints in the superior and five in the inferior flagella, the accessory flagellum 2-jointed, 1st joint long, narrow, and cylindrical, and the apical joint almost rudimentary. The smaller of the two females has five joints in both superior and inferior flagella. Two of the antennae of the larger animal are broken, those remaining being the superior on the left side with seven joints, and the inferior on the right side with six. Sars (**30**), p. 596, gives five joints for the superior and four for the inferior.

I have been able to compare the *Huxley* specimens with some taken by Mr. Crawshay near the Eddystone. In these, the increase in the number of the joints with growth is plainly shown. One young male, 3·75 mm. long, with the thumb just commencing to appear on the hand of Gnath. 2, had four joints in the superior and four in the inferior flagellum; a larger specimen, 4·25 mm., with the thumb further developed, had five in the superior and four in the inferior; two large fully adult males, 5·5 mm., with the bifid apex to the thumb, also had five in the superior and four in the inferior. Of the females, the smallest ovigerous one, 3 mm., had four in the superior, three in the inferior; other young ovigerous females, 4 mm., had four joints in both superior and inferior. In the larger ones, unfortunately, the antennae were more or less broken; one had five joints in both inferior flagella; the largest, 6·5 mm. long, had six joints on the right and five on the left superior, five joints on the left inferior; another had six joints on the right superior, four in the right and three in the left inferior.

There are two forms of antennae in both sexes in *falcata*. In the one form the whole of the inferior antenna is swollen, and all the proximal joints of the flagellum coalesced, so that only three joints can be traced, the long, swollen, coalesced 1st joint, a small stout joint, and a rudimentary terminal one; the accessory flagellum is 1-jointed and swollen. Dense fascicles of plumose setae are developed on the long joint of the flagellum and on the distal portion of the last joint of the peduncle. In the other form the inferior antenna is more slender; the joints of the flagellum are distinct five or six in number, the number frequently different on one side from the other; no plumose setae are developed, but the curved sensory spines are stronger and more numerous; the accessory flagellum is 2-jointed and cylindrical. This form is certainly near *pusilla*, but can be easily distinguished from it; it is much more heavily built; the last joint of the peduncle lacks the fringe of long setae, being only sparsely setose; the joints of the flagellum are short and thick; and the sensory spines of the flagellum also show a marked difference, being short and thick, and curved like hooks, while in *pusilla* they are long and slender, and hardly curved at all. The fascicles of plumose setae cannot be used as a distinguishing character, seeing that it is only in certain stages of development that they occur in *falcata*.

Gnathopod 2. All the specimens taken by the *Huxley* are fully adult, the two males showing the characteristic development of the thumb. There are two forms of the hand in *falcata*, correlated with the two forms of antenna. In the first form the hand is broad and swollen, thumb broad and truncate at the apex. In the second form the hand long and slender, with fascicles of plumose setae along the palmar margin, and the thumb is long and narrow, tapering to a subacute point. But in all the stages of development in *falcata* the apical margin of the thumb is entire, with not the slightest tendency to the bifid apex of the adult *pusilla*. The young male of *pusilla* resembles the young male of the second form of *falcata* in the development of the thumb, cf. figures given by Sars (**30**), pl. 212, p. 2, ♂ ÷, and pl. 213, 1, p. 2, ♂ ÷.

Norman (**27**), p. 93, considers the *Podocerus variegatus* of Bate and Westwood (not Leach) to be the female of *pusilla*, but an examination of Bate's specimens in the British Museum has shown it to be the female of the first form of *falcata*; it has the broad, heavily-built, inferior antenna, the short stout joints in the flagellum, and the second sideplate and hand characteristic of this species.

The finger in *falcata* develops with age an angular projection on the inner margin, very noticeable in the full-grown male. The finger in *pusilla* shows no sign of it.

The *Peraeopods* afford another character for distinguishing the species. In *pusilla* they are much longer in proportion to the animal's size, and more slender, the 6th and 7th joints more elongate; 7th joint lightly curved, not falciform as in *falcata*; 6th joint lacking the stout sensory spines carried by the latter species.

Distribution. *J. pusilla* appears to be a deep-water form, there being no authentic record of its occurrence in a less depth than 20 fathoms. *J. falcata*, on the other hand, is a littoral or sub-littoral form, building its nests in the algae and hydroids on buoys, dock-piles and rocks near the shore.

J. pusilla has been recorded by:—

Sars (**29**), p. 112, as *Podocerus minutus*, and (**30**), p. 597, as *Podocerus pusillus*, from the south and west coasts of Norway, and as far north as Hammerfest, "clinging to hydroidae growing in depths varying from 20–100 fathoms."

Robertson (**28**), p. 27, records an amphipod as *P. minutus* taken amongst the algae on the timbers of Millport Pier, Cumbrae. I have not been able to trace his specimen, but I consider this record is open to doubt, and that in all probability he mistook a young stage of *falcata* for Sars's species.

Scott (**32a**), as *Podocerus pusillus*, from the Firth of Forth.

Walker (**45**), p. 314, as *P. pusillus*, off Port Erin, no depth stated.

Norman (**27**), p. 93, records under *Bruzeliella pusilla*, "two females taken at Falmouth in 1884," but as he identified these with the *Podocerus variegatus* of Bate and Westwood, they are therefore, as I have shown above, females of the "first form" of *falcata*.

Chevreux (**9**), p. 315, as *P. minutus* on *Maia*, dredged south-west of Belle Isle in 80–100 m.

To these records must be added:—

Thirteen specimens taken by Mr. Crawshay, in June, 1906, 20 m. south-west of the Eddystone, in 42 fathoms; 5 males, 8 ovigerous females; from sponge coating *Inachus dorsettensis;* and numerous specimens taken by Mr. Barnard, March–April, 1911, near the Eddystone, also from sponge coating *Inachus*.

The *Huxley* specimens were from very deep water; one specimen, a female, from $\frac{i}{444}$ fathoms; and three specimens, 1 male and 2 females, from 412 fathoms, all full-grown animals.

FAM. COROPHIIDAE.

GEN. **Erichthonius**, Milne-Edwards.

Erichthonius brasiliensis (Dana).

(Stebbing (**41**), pp. 671 and 740.)

STATION XII. 246 fathoms; 1 specimen, an ovigerous female, 6 mm.

„ XIII. 412 fathoms; 2 specimens, females, 1 measuring 5 mm. in length, with eggs; the larger one 6 mm., with six young ones still remaining in the marsupium; length of young, 1·25 mm.

The greatest depth hitherto recorded for this species is given by Chevreux as 130 metres.

Previous records: by Chevreux (**14**), p. 108; and (**9**) pp. 289, 301, and 316, found on *Maia squinado*, trawled in 60–80 metres, as well as on algae growing on the bottom.

GEN. **Unciola**, Say.

Unciola planipes, Norman.

(Stebbing (**41**), p. 679.)

STATION IV. One specimen, an ovigerous female, 6·5 mm. long; taken in a tow-net attached to the dredge working at the bottom.

Recorded by Chevreux (**14**), p. 110, from 50–180 m.

GEN. **Siphonoecetes**, Kröyer.

Siphonoecetes colletti, Boeck.

(Stebbing (**41**), p. 683.)

STATION V. Three specimens, 2 males and 1 female of 6 mm. length.
„ IX. One specimen, a male, 5·5 mm.
„ XII. Four specimens, all males, 7·5–8 mm.

Previous records: by Bonnier (**5**), p. 347, as *S. typicus* Kröyer; and by Chevreux (**9**), p. 317, as *S. typicus*, and (**14**) p. 108 as *S. colletti*. The greatest depth recorded by Chevreux is 180 metres; by the *Huxley* at Station XII, 246 fathoms.

FAM. **PODOCERIDAE.**

GEN. **Laetmatophilus**, Bruzelius.

Laetmatophilus tuberculatus, Bruz.

1859. *Laetmatophilus tuberculatus* Bruzelius (**8**), p. 11, Taf. 1, fig. 1.
1862. *Cyrtophium tuberculatum* Spence Bate (**2**), p. 275, pl. 46, fig. 9.
1868. *Cyrtophium armatum* Norman (**25**), p. 285.
1876. *Laetmatophilus tuberculatus* Boeck (**4**), p. 663.
„ „ *spinosissimus* „ „ p. 665.
1894. „ *tuberculatus* Sars (**30**), p. 630, pl. 226.
„ „ *armatus* „ „ p. 632, pl. 227, fig. 1.
1895. „ „ Norman (**25a**), p. 493.
1906. „ *tuberculatus* Stebbing (**41**), p. 696.
„ *armatus* „ „ p. 697.

STATION XIII. One specimen, a male, 4·5 mm. long.

This species was established by Bruzelius in 1859. In 1868 Norman described a specimen from the Shetland Isles under the name of *Cyrtophium armatum*. He noted its resemblance to Bruzelius's species, but considered it sufficiently distinguished from it by the following characters: "much more strongly tuberculated; and the gnathopods of different structure, the first smaller, the second larger, the hand broader and the basos spined." Sars in 1894, although he described the two species as distinct because of the peculiar armature of the body in *armatus*, was inclined to consider this latter form as merely a deep-sea variety of *tuberculatus*, giving the range of distribution as 20–50 fathoms for *tuberculatus* and as 50–300 fathoms for *armatus*.

The specimen taken by the *Huxley* was a large male, 4·5 mm. in length, with the spinose armature even more accentuated than in the figure given by Sars for *armatus*. Through the kindness of Canon

Norman I have been able to compare it with a Norwegian specimen of *tuberculatus*, also a large male, 4 mm. in length, and as a result of this examination, I think there can be no question but that the two species are identical, *armatus* being the fully-developed animal.

As I have shown before (**35**), p. 849, the Amphipoda undergo considerable modification, even after reaching sexual maturity, the characters most noticeably affected being: the *antennae*, the number of the joints in the flagella increasing and the proportions of the peduncle joints altering with growth; the *second gnathopods*, the hand of which increases in size and alters in shape to a far greater degree than the hand of the first gnathopod; and the chitinous *cuticle* of the body, spinose processes developing, and growing longer, more acute, and more numerous with age. An example of the development of the processes of the cuticle, bearing on the present case, will be found in the paper above referred to (p. 870), where the stages of growth in one species were traced; the cuticle in the very young animal was perfectly smooth, the spinose processes commencing as slight swellings, and developing at maturity into rounded upstanding tubercles, only assuming their characteristic shape with the further development of the animal.

It will be seen that the distinguishing points given by Norman to differentiate his species from Bruzelius's are precisely those which would be influenced by age and growth. With regard to the first point—the stronger armature of the body—I found on examining the specimen of *tuberculatus* that the tubercles are of exactly the same number and arranged in exactly the same manner as the spine-processes of *armatus*, those on the last peraeon-segment and the first two pleon-segments being larger than the others, as Norman noted in *armatus*. The 1st segment has two, one behind the other; the 2nd segment three, one median in front of the transverse furrow, followed by two side by side; the remaining peraeon-segments and two first pleon-segments each have a swelling in front of the furrow, with two tubercles side by side behind. This agrees with Bruzelius's description;* he states (p. 11) that the 2nd, 3rd, 4th, and 5th segments carry three tubercles each, one in front of the other two; but, except on the 2nd segment, as described above, the anterior tubercle is not distinctly defined. Boeck's account is the same. Sars, however,

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* "Tvärs öfver dess ryggsida går en intryckning, och på ryggen bär det två små knölar. Det andra, tredje, fjerde och femte segmentet hafva, liksom det första, en tvärs öfver ryggen gående intryckning, och tre små knölar, den ena framför de två andra. . . . Det sjette och sjunde segmentet, som äro hopvuxna med hvarandra, hafva på ryggen två par knölar. Deras epimerer äro åtskilda. De tre första abdominal-segmenterna äro korta, och af dessa bära de två första två knölar på ryggen." Bruz. (p. 11).

appears to have had younger specimens to deal with than either Bruzelius or Boeck. His description (p. 630) is as follows: "1st segment with two succeeding dorsal tubercles; 2nd segment with a slight tubercle in front of the sulcus; the succeeding segments scarcely tubercular, but having the dorsal contour somewhat rugged."

There is little to add to the full descriptions of the species, already referred to. In both specimens the 6th and 7th peraeon-segments are coalesced; the finger of Gnathopod 1 is bifid at the apex and furnished on both margins with small setae; the finger of Gnathopod 2 has the marginal setae as in Gnath. 1, and two specialized bristles at the articulation, one simple and one plumose; the pleopods have no cleft spines; the coupling-spines are of the same construction as those figured by Stebbing for *L. purus* (**39**), pl. 132, six in the older animal (*armatus*), and rami 9-jointed, five coupling-spines in *tuberculatus* and rami 8-jointed.

The species has only been recorded hitherto from the coast of Norway and the Shetland Islands.

TRIBE CYAMIDEA. STEBBING (**42**), p. 464.

FAM. **CAPRELLIDAE.**

GEN. **Pseudoprotella**, Mayer.

Pseudoprotella phasma (Montagu).

(For synonymy and distribution, see Mayer (**19**), p. 29; (**20**), p. 19; and (**21**), p. 37.)

STATION XIII. Five specimens; 1 female measuring 11 mm., and 4 males, 10–15 mm. in length.

This species has been frequently taken on the oceanic coast of France, but the depth at which the *Huxley* specimens were trawled, 412 fathoms, appears to be the greatest yet recorded for its occurrence.

GEN. **Pariambus**, Stebbing (**39**), p. 1268.

Pariambus typicus (Kröyer).

(See Mayer, *Podalirius typicus* (**19**), p. 75; (**20**), p. 92; and (**21**), p. 63.)

STATION V. One specimen, a female with ova, measuring 3 mm., depth 109 fathoms.

Recorded from the Bay of Biscay by Chevreux, found on *Maia*, *Asterias*, etc.

TRIBE PHRONIMIDEA, STEBBING (**42**), p. 473.

FAM. **VIBILIIDAE.**

GEN. **Vibilia,** Milne Edwards.

Vibilia armata, Bovallius.

STATION VIII. Surface: 1 specimen, a female, measuring 10 mm.

Recorded before from the Bay of Biscay by Stebbing (**40**), p. 31.

FAM. **HYPERIIDAE.**

GEN. **Hyperia Latreille.**

Hyperia galba (Montagu).

STATION X. Seven specimens. The largest, a female carrying eggs, measured 23 mm.; of the others 2 were ovigerous females, 16 mm.; 1 a large male, 14 mm.; the three remaining, 1 male and 2 females, were immature, the smallest 5·5 mm. in length.

GEN. **Euthemisto,** Bovallius.

Euthemisto compressa (Goës).

All the specimens were acutely carinate dorsally, but in many (cf. also the specimen described by Stebbing (**40**), p. 38) the projecting dorsal teeth were not developed.

STATION IV. Ten specimens; 7 ovigerous females, the largest 5·5 mm. long, 1 young male, and 2 adult males, 5 mm.

STATION X. 42 specimens; 36 females and 6 males; the largest measured 7 mm.

I agree with Tattersall (**43**), p. 36, in considering *E. gracilipes* Norman as a young stage of *E. compressa.* Both forms have been recorded from the Western Stations by the Int. Council Investigations.

Euthemisto bispinosa (Boeck).

STATION X. Two specimens; ovigerous females, the larger 8 mm. in length; the dorsal spinose processes not much developed in either.

With this record it will be interesting to compare a haul made on May 16, 1909, by the *Huxley,* not far from Station X., in 47° 47′ N., 7° 44′ W., when the tow-nets were choked with an immense swarm of large specimens of this species. In this haul the females outnumbered the males by three to one. They were much larger on the average, the largest females in the sample examined by me measuring 31 mm. from rostrum to tip of uropods, while the largest males were only 18–19 mm. There were only a very few small ones, and of these the smallest was 9 mm. long. The two specimens from Station X agree in all structural details with these large ones, the only difference being the degree of development of the dorsal processes on the two last peraeon-segments and the two first pleon-segments, which in the larger specimens are greatly produced. The variation in size is not confined to this species. Stebbing has noted a similar case in *Parathemisto oblivia* (**40**), p. 37; and it was one of Norman's principal reasons for separating *E. gracilipes* from *E. compressa* (**27**), p. 54.

The pouches of all the females (May, 1909) were greatly distended with either young just hatched or with eggs nearly hatched. Owing to the extrusion of most of the contents of the pouches it was impossible to estimate the number carried by any one female. It must, however, be considerable; one female, 20 mm. long, had 71 young, each measuring 1·5 mm., still remaining in the pouch. In view of Sars's remarks as to the peculiar armature of the 6th joint of the 3rd peraeopod forming a constant specific character in the very young specimen equally with the adult, it may be worth while to note here that in the larval *E. bispinosa* all five peraeopods are practically subequal in length, and the 3rd is not distinguishable from the others. The proportions of the joints are quite different also, e.g. the finger of the 3rd peraeopod is nearly as long as the preceding joint.

FAM. **LYCAEIDAE.**

GEN. **Brachyscelus,** Bate.

Brachyscelus crusculum, Sp. Bate.

STATION X. One specimen, an ovigerous female, 8·5 mm. long.
,, XII. One specimen, a large ovigerous female, 17·5 mm.

For the discussion as to the identity of *Thamyris mediterranea* Claus with *Brachyscelus crusculum* Sp. Bate, see Norman (**26**), p. 134; Tattersall (**43**), p. 26; and Stebbing (**40**), p. 41. I have not seen any males of this species, but an examination of the two female specimens mentioned above would seem to support Norman's view that *T. mediterranea* is only a young stage of *B. crusculum*. In the small female the 3rd uropods reach to nearly the level of the telson, as in Senna's figure 10 (**33**), p. 8, while in the large female the telson extends considerably beyond them, as in Chevreux's figure 8 (**11**), p. 74.

LIST OF SPECIES, AND THE STATIONS AT WHICH THEY OCCURRED.

STATION NO.	II	IV	V	VII	VIII	IX	X	XI	XII	XIII
Latitude, N. Longitude, W. Depth in fathoms Bottom deposit	48° 24′ 6° 28′ 75	47° 48′ 7° 25′ 109 Coarse sand and broken shells.	47° 48′ 7° 46′ 109 Coarse sand and shells.	47° 36′ 7° 31′ $\frac{\cdot}{444}$	47° 30′ 7° 31′ Surface.	48° 7′ 8° 13′ 240 Fine sand.	48° 7′ 8° 13′ 146 Fine sand.	48° 10′ 8° 11′ 146 Fine sand.	48° 7½′ 8° 13′ 246 Fine sand.	48° 7½′ 8° 13′ Sand, mud, and hard ground.
Trischizostoma nicæense	...	...	...	...	...	...	...	...	1. f.	...
Ichnopus spinicornis	...	...	...	...	...	...	6. f.	...	...	...
Tmetonyx similis	1. f.	...	...	...	...	...	...	...	...	...
Tryphosites alleni n. sp.	...	...	...	...	...	...	...	...	2. f.	...
Proboloides gregarius	...	...	...	...	...	...	...	...	...	1. f.
Cressa dubia	...	...	...	1. m.	...	...	...	...	...	...
Stenothoe richardi	...	...	...	...	...	...	...	...	...	1. m.
Iphimedia obesa	...	...	1. f.	...	...	...	...	...	...	...
Syrrhoites walkeri	...	...	...	...	...	...	...	...	1. f.	...
Syrrhoe affinis	...	...	...	...	...	2. f.	...	...	...	...
Apherusa bispinosa	...	44 m. and f.	...	...	...	...	3. 1 m.	...	...	...
Sympleustes latipes	...	...	...	...	...	...	...	...	...	3.
Sympleustes grandimanus	...	...	...	...	...	...	...	...	...	5. f.
Sympleustes glaber	1. f.	...	...	...	...	...	...	...	...	...
Epimeria parasitica	...	...	...	...	...	20	...	...	23.	...
Epimeria cornigera	2.	...	63	...	...	2	...	3	1.	...
Nototropis vedlomensis	...	1. f.	...	...	...	...	...	...	...	...
Eusirus longipes	...	3 m.	...	...	...	...	...	...	...	...
Eusirus biscayensis	...	...	...	...	...	...	...	...	7. 1 m.	...
Rhachotropis helleri	...	...	...	...	...	...	...	...	20. 1 m.	...
Rhachotropis rostrata	...	...	...	...	...	...	...	...	4. m.	...
Maera tenuimana	...	...	1 m.	...	...	...	...	...	...	...
Leptocheirus pectinatus	1. f.	...	...	...	...	...	...	...	...	...
Jassa pusilla	...	...	...	1. f.	...	...	...	...	...	3. 2 m.
Erichthonius brasiliensis	...	...	...	...	...	...	...	...	1. f.	2. f.
Unciola planipes	...	1. f.	...	...	...	...	...	...	...	...
Siphonoecetes colletti	...	...	3. 2 m.	...	...	1. m.	...	...	4. m.	...
Laetmatophilus tuberculatus	...	...	...	...	...	...	...	...	...	1. m.
Pseudoprotella phasma	...	...	...	...	...	...	...	...	...	5. 4 m.
Pariambus typicus	...	...	1. f.	...	...	...	...	...	...	...
Vibilia armata	...	...	...	...	1. f.	...	...	...	...	...
Hyperia galba	...	...	...	...	...	...	7. 2 m.	...	...	...
Euthemisto compressa	...	10. 3m.	...	...	...	...	42. 6 m.	...	...	...
Euthemisto bispinosa	...	...	...	...	...	...	2. f.	...	...	...
Brachyscelus crusculum	...	...	...	...	...	...	1. f.	...	1. f.	...

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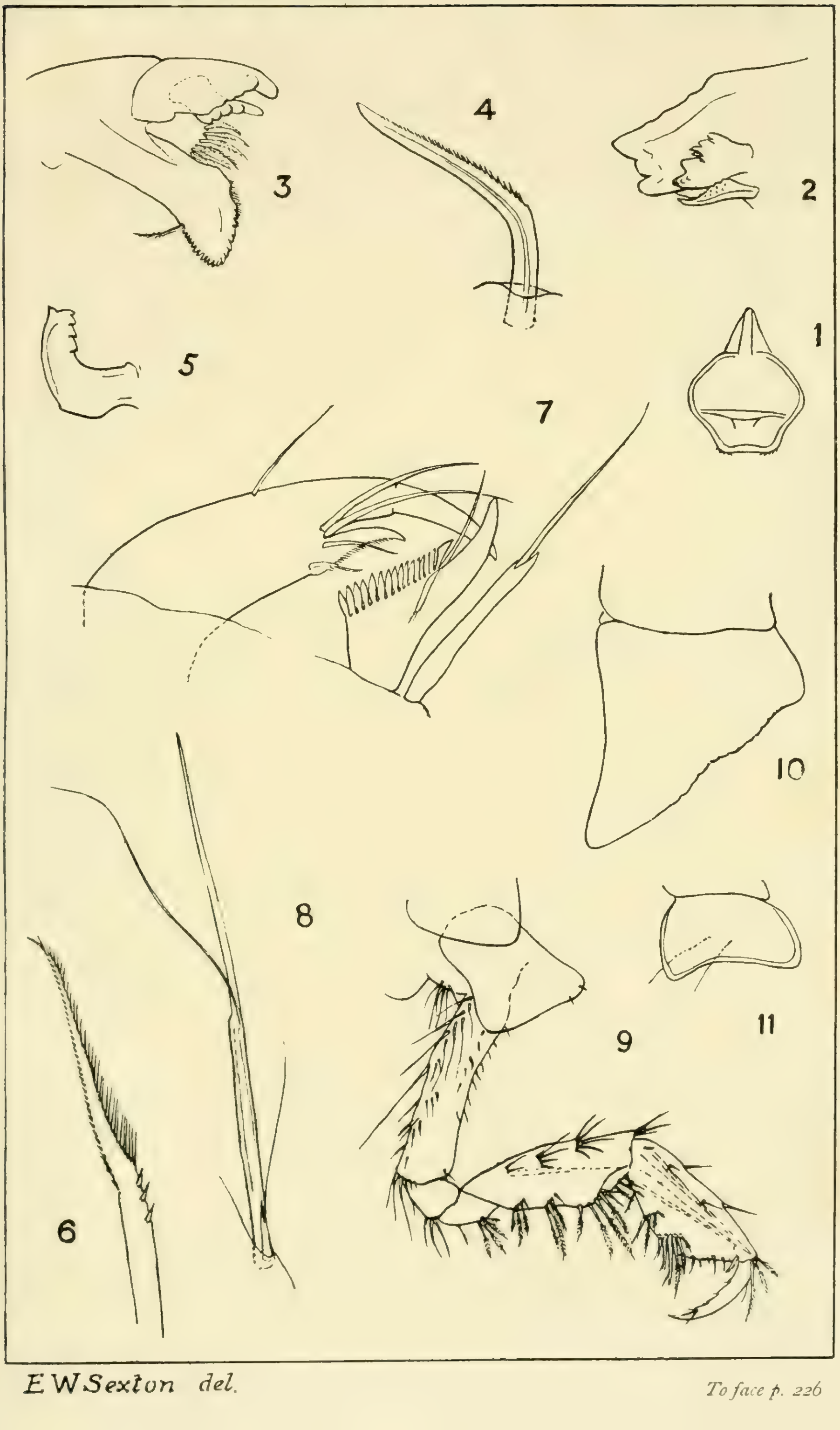
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EXPLANATION OF PLATE III.

FIG.	1. Upper Lip . . .	*Syrrhoe affinis* Chevreux	x 42
,,	2. Cutting plate, accessory plate, and spine. Right mandible	*Syrrhoe affinis* Chevreux	x145
,,	3. Left mandible . .	,, ,, ,,	x 75
,,	4. Curved spine, inner plate, Maxillipeds	,, ,, ,,	x435
,,	5. Coupling-spine ,, ,, ,,	,, ,, ,,	x435
,,	6. Bristle from joint 5, gnathopod 1	,, ,, ,,	x380
,,	7. Finger and palmar spine, upper surface, gnathopod 2	*Syrrhoe affinis* Chevreux	x380
,,	8. Sensory spines from distal end of joint 6, peraeopod 3	*Syrrhoe affinis* Chevreux	x265
,,	9. Gnathopod 1, ovigerous female	*Apherusa bispinosa* (Bate)	x 75
,,	10. Sideplate 2, adult male, 11 mm. long	*Jassa falcata* (Montagu)	x 42
,,	11. Sideplate 2, adult male, 5·5 mm. long	*Jassa pusilla* (Sars)	x 42

On Some Colour Variations and Adaptations in *Actiniae*.

By

Chas. L. Walton.

THE significance of the colouration of various *Actiniaria* has been of much interest to me for some time, and particularly the extreme variability displayed by certain of the most abundant species. Descriptions of colouration and coloured plates help but little toward elucidating these problems, the examination of numbers of the animals living in their natural environment being absolutely essential before any conclusions can be drawn.

Taken as a whole, the colouration of *Actinians* seems to come under the following heads:—

I. Warning.
II. Aggressive.
III. Protective.
IV. Colours with some special physiological significance.

Examination has shown that these leading features are not necessarily confined to a species, or even to an individual, which may combine them in varying degrees, though one is usually partially or wholly dominant, this being chiefly governed by the environment. In other words, I believe that the colouration of a species or individual may be adaptable to more than one end; that local circumstances and environment govern this, and that those species which become most effectually adapted to these environmental circumstances will be everywhere found to be the most abundant.

Naturally this adaptation is not confined to colouration, but is observable in many other details, some of which will be mentioned, but the colouration is the main factor to which I wish to draw attention.

I have assembled a considerable mass of data, from which I shall here detail a selection of what I deem the most suggestive and instructive.

Actinia equina, Linn. This is quite the most abundant British species, and is extremely variable in colour; shades of red, brown, green, etc., alone or variously combined, are all abundant; several of the varieties are so well marked as to have been considered distinct species at various times.

While working at Aberystwyth, in Wales, I was struck, while collecting, by the fact that light had a great deal to do with the distribution of the variously coloured forms, those from exposed positions being dark red, etc., while those from under stones, or seaweed, or from caves, were mostly of light shades, or green. This has also been recorded for another member of the genus, *Actinia tenebrosa*, Farquhar, from New Zealand. In describing this species the author says: "This is the southern representative of the European species *A. equina*," etc. "This species is a good example of the effects of light on the colours of animals. Full-grown individuals, in situations well exposed to the rays of the sun, have the column greenish, or brownish black, and the disk and tentacles dusky crimson, while those on the under side of overhanging stones are reddish brown or crimson, the depth of colour varying according to the amount of light that reaches them. Specimens on the vertical sides of rocks (their favourite habitat) often have a patch of reddish brown on the side turned away from the light. I found a specimen under a large stone which had evidently never been in the light: the whole animal was yellowish white with a slightly greenish tinge."

No remarks are made as to any variation in the size, number, or colour of the acrorhagi, or "marginal spherules."

Investigation of Aberystwyth specimens of *A. equina* showed that a correlation exists between environment and these organs, which are as a rule of a bright blue. M. Haime (quoted by Gosse) gives the following table of number of spherules:—

18 if 5th cycle of tentacles not developed.
24 if 5 or 5½ cycles are developed.
48 if 6 cycles are developed.

My observations on some hundreds of specimens prove this to be correct if an average be taken—in effect there are considerable differences. Those individuals which are of dark shades and occur in exposed positions, tend to possess more acrorhagi than those which live in sheltered situations and which are of paler shades. In these last also the acrorhagi are fewer, smaller, and of a pale blue, whilst in the darker specimens the acrorhagi are larger, of a much deeper blue, and often irregular (bilobed, etc.) in form. The colour of the acrorhagi (lighter and darker) is of course due to the same circumstances that cause the colour differences in the rest of the individual; but the variation in size is not necessarily due to this cause, and in all probability results from the different environment. It seems probable that these organs are defensive (possibly offensive), and they certainly contain many nematocysts, and their colour may be interpreted as "warning." These organs are not plainly visible during complete expansion, and not at all during retraction; but when the anemone is startled (if the blue basal line be touched, etc.) the tentacles are partially withdrawn and the acrorhagi are then exposed and show very plainly. A good deal has been written respecting these organs, and they have been referred to as eyes, special sense organs, etc.

Messrs. G. Y. and A. F. Dixon in treating of this species, besides mentioning irregularities of form and colour, say: "Each spherule contains a prolongation of the general body cavity, and can consequently be dilated at will," and they relate that a specimen dilated greatly, and brought the spherules into contact with the glass of the aquarium. When the organs contracted and withdrew, portions remained forming conspicuous blue spots. Examination of these showed numerous spindle-shaped cells, as described by Hollard (Ann. de Sci. Nat. Zool., 3 ser., vol. xv., p. 272), and they conclude that the anemone had evidently engaged in an attempt to sting the glass front.

I have never been able to demonstrate the discharge of nematocysts from these organs, but have on more than one occasion observed great distention of the acrorhagi, so that the increased weight caused the anemone to bend over on one side, and so bring the projecting organs into contact with objects which happened to be in close proximity.

The pale specimens with few acrorhagi are frequently as large as those darker ones with many, so that the increase must be either due to more light, or, owing to inhabiting more exposed positions, there is greater need of protection by increased batteries of nematocysts.

Sagartia miniata (Gosse) is under most conditions to be classed amongst species whose colouration is of a "warning" nature, and is amply provided with acontia which are very freely emitted. As a rule they form very conspicuous objects on the sides of rocky pools. I have examined hundreds of specimens from the North Sea, which though showing many minor variations were all of the same type even when from a depth of 40 to 47 fathoms, where the bottom was black mud (see *Actiniae* of the s.s. *Huxley*, 1907); but Mr. L. R. Crawshay showed me living specimens from the Bay of Biscay deep water in which the colouration was dull, the scarlet being absent, probably owing to lack of light. This variety entirely lacks the bright colours of the typical form. I recently found a specimen which harmonised with its surroundings in a remarkable manner. It was affixed to the bottom of a rock pool at East Pentire, Newquay, Cornwall. This pool was full of a growth of dark *Algae*, with which colonies of red species showed as thin, irregular, red streaks and lines. The *S. miniata* was very large, and its outline most irregular; the scarlet-cored outer row of tentacles so exactly resembled the red *Algae*, and the rest of the animal the dark *Algae*, as to render it most difficult of detection. I watched for some time and observed an amphipod deliberately swim into the scarlet tentacles, doubtless deceived by their resemblance to the *Algae*.

Cereus pedunculatus (*Sagartia bellis*). I had long considered that many of the numerous varieties were to be interpreted as aggressive, but a careful study of pools at Newquay, etc., brought out additional and interesting cases of adaptations.

In pools similar to that described above, a variety of a dusky umber hue was abundant, with frequently streaks and shades of red upon the inner tentacles and disk. This type predominated in those pools where the *Algae* were dark, with red species intermingled. When fully expanded the anemones resembled the dark weeds; when alarmed and partially contracted the red showed up, and the animals were still in harmony with their surroundings; if further irritated, the edges of the salver-shaped margin were folded over and the anemones then formed bluish purple patches against a dark background: possibly a warning colouration. A second variant found in pools only a few yards from those just mentioned was lighter in colour, more variegated, and had the tentacles merely tinged with red, or not at all. This type was found in pools where "corallines" were the main growth, and when these specimens closed, their columns were of a pink shade (seldom purple), and thus in accordance with the environment instead of in contrast, as in the last examples.

On muddy shores the summit is dark, as I have observed at Plymouth, etc. These examples could be backed by many more from varying localities. In all, the complex colouring of the disk and tentacles approximates to the colour scheme of the pool, or portion of pool in which the individual has its habitat. I quote from my notes made on the rocks at Polzeath, near Padstow, Cornwall: "*C. pedunculatus* is fairly abundant on this (the Pentire) side of the bay, and I have examined a considerable number. The rocks hereabouts are reddish or greenish, and the pools are often coated with pink *Algae*. In the first I examined a dull red specimen was expanded, and just the shade of numerous tufts of the brown seaweeds growing around it; when closed the margin was of a pink hue, exactly that of the rock around it. Near by were others growing amidst pink corallines, the tips of which were dead and white; these were of a dull pink, freckled all over with white, and thus so resembled the corallines as to quite deceive me at first.

"Many were expanded at the mouth of cracks and crevices, into which they retired when touched; and most of these had the summit covered with fragments of shell, etc., attached to the suckers of the upper portion of the column, so that when contracted there remained no sign of the anemone. I ascertained that in these the colour of the under side of the waved margin was not in agreement with the environment.

"Throughout numerous pools in ever-changing conditions, this species in each case varied to suit the colour scheme, importing shades of red or yellow, or both, in threads and streaks, and so on through innumerable variations."

I have frequently had to resort to feeling before I could be sure whether what I saw was a tuft of some seaweed or a specimen of *C. pedunculatus.*

That this resemblance is of protective value is highly probable, but from numerous observations, both under natural conditions and in aquaria, of small *Crustacea* mistaking the anemones for *Algae* and so being caught and devoured, I consider it to be also, if not even predominantly, aggressive.

Specimens living under stones are usually of small size, and when so situated that they can receive even a modicum of light are in colour merely pale editions of the prevailing local varieties; but when, as is frequently the case, specimens are obtained from beneath several layers of stones and weeds and thus have lived in darkness, the colours are usually light shades of chrome-yellow, together with crimson and scarlet, generally in lines and streaks, the columns as a rule colourless. A certain proportion of these shades frequently forms some portion of the mixed colouration of the surface forms, and the curious predominance in cases where adaptive and selective conditions are in abeyance may point to a form originally so coloured.

Gephyra dohrnii, von Koch, I consider to be a true instance of protective resemblance. At the Marine Biological Laboratory, Plymouth, I recently examined several specimens living upon *Eunicella cavolini*, von Koch. An adult exactly agreed with the general tone of the *Eunicella*, but a smaller and younger one did not accord so well, being paler, and when expanded showed a number of irregular opaque white streaks upon the disk and tentacles. In the adults there were merely a few specks in the area of the mouth. This may also point to an ancestry not resembling the *Eunicella* in colour, or at any rate striped in the usual *Sagartian* style? That *Eunicella* is in a great measure protected from fish attacks finds support in the colouration of specimens of *Tritonea plebeia* and *Ovula patula* that dwell thereon.

A. C. Haddon, in his account of *Gephyra* from the Irish coast, figures three-colour variants, all of which occurred upon *Tubularia*. Fig 3, pl. xxxi., shows a "cherry-coloured" variety, which must have been in close accord with the "polyps" of the *Tubularia;* the others are much lighter and more resemble the forms from *Eunicella*. Andres figures a yellow *Gorgonid,* and the anemone whitish tinged with yellow, but his description gives "Colonna carnicina."

Sagartia undata (*S. troglodytes*). Although fairly well acquainted with several varieties, I regret that since I became interested in this subject I have not met with it in any abundance, and hence cannot say much regarding this most variable species. Gosse says (p. 92): "In the shallow pools that floor the largest caves at St. Catherine's, Tenby, the varieties *scolapacina* and *aurora* spread their pretty blossom faces at the bottom of the clear water. And yet it is not easy to discover them even when scores are thus exposed, for the mottled colouring of the disk and tentacles is so like that of the sand and mud of the pools that even a practised eye may overlook them without the closest searching." Others with orange disk, or tentacles, are evidently warningly coloured. Gosse (p. 91) gives "variety *hesperus*. Wholly pure white, gradually acquiring colour in a confinement of some months" (Lundy, W. Brodrick in litt.).

Tealia coriacea (*crassicornis*). Mr. F. Slade, of Horniman's Museum, in a letter to my friend Dr. Fleure, noted that specimens of *Tealia coriacea* (*crassicornis*) sent from Aberystwyth were better coloured and altogether better animals than those from the chalk of Sussex, and this I have since seen for myself. Gosse (p. 211) says of deep water specimens, "all colour lost in a semi-pellucid dusky grey . . . and specimens usually very large." I have examined large numbers of this deep-water form. H. N. Moseley describes from the Severn estuary, near Aust and New Passages, large numbers of *Actinia*, and *Tealia* (near Weston-super-Mare, very common), the colours of all dull, especially *Actinia*, which were dirty white or pale olive, and the *Tealia* transparent green. Near Aust were found a few *Tealia* vivid red, nearly as bright as marine specimens. "They were attached to a rocky channel, and when the tide fell a constant stream of water came from a large pool above in which the mud settled and clear water flowed off."

Anemonia sulcata is a decidedly puzzling species. Showing considerable variation, there are two varieties which are predominant:

the green with purple-tipped tentacles, and the brown and grey. Both these are most abundant, frequently inhabiting the same pool. The species is provided with very powerful sting cells (I have myself been well "nettled" when handling large specimens) and is evidently sufficiently protected from fish attacks, or at any rate to a considerable extent. Both varieties when under water present a decided resemblance to masses of *Algae*, and doubtless obtain much food in the form of deluded *Crustacea*, and I am inclined to consider the colouration as partially aggressive, with secondary warning colours in the purple tips of the tentacles, and the occasional scarlet area on the lower portion of those organs. It is to be noted that these characters usually only accompany the green variety named *smaragdina* by Gosse. The scarlet area on the tentacles is mentioned by Gosse (p. 162) as occurring at Herm, and I have seen it in varying degrees on several occasions. I will give one instance from my notes. Near low-water level at Polzeath (N. Cornwall) I came across two enormous individuals attached side by side. The columns were rich purple-brown, the tentacles some four or five inches in length, a most vivid green, and purple-tipped, while the bases of the tentacles resembled flame-coloured silk. I touched them with my finger, knowing that irritation usually produces an increase of brilliance in this species; the tentacles at once bent inward, thus exposing the lustrous, glowing areas to plainer view. F. G. A. Stuckey in his *Review of New Zealand Actiniara* says of *Anemonia olivacea*, Hutton: "This species is found in rock pools, often inhabiting quite small pot holes on the upper part of the rocks. Its colour is strongly protective." I have examined numbers on the west coast of the N. Island, and consider that this also is a case of "aggressive" colouration, as it greatly resembles tufts of green *Algae*.

I had frequently noted in many *Sagartids* that in some specimens the acontia would be emitted on the slightest provocation, while in others they were only protruded after severe irritation. I now regard this as largely due to varying environmental conditions. Those individuals which have been exposed to constant friction only emit the acontia after considerable irritation, whilst those which have been living in quiet and undisturbed surroundings emit the acontia with freedom and at the least touch. My reference to constant friction applies to individuals which, living within tide marks, are exposed to constant boil of surf, causing abrasion by shingle, etc., or constantly brushed by *Algae*.

This control of acontia is closely connected with and analogous to the control of nematocysts, etc., referred to in a former paper ("Notes on the Habits of some Sea Anemones," by H. J. Fleure and C. L. Walton), and is the result of differentiating reactions and a persistent inhibitory stimulus due to the constant repetition of such causes as induced the same, and which alone probably prevent its lapsing. We have already shown that such impressions are evanescent, and it would appear that the whole tissues of these animals are in what may perhaps be termed a more or less plastic state, and hence (at least in many forms) varying environmental conditions readily affect them, and adaptations rapidly result. Hence the abundance of very variable species.

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Notes on various British Anthozoa.

By

Chas. L. Walton.

I. **Sagartia ornata** (Holdsworth).

THIS species is described and figured by Gosse in his *Actinologia Britannica*, quoting its original discoverer Holdsworth, who obtained a number of specimens at the entrance of Dartmouth harbour from among the roots of *Laminaria*. In Section III of the Appendix, Gosse (p. 355) adds: "I have taken this at Torquay. It has also been found at Mizen Head, and sent me from Banff. The markings are true to the description, and leave no doubt of its distinctness as a species."

I recently (July, 1910) obtained specimens at Aberystwyth, attached to a fixed stone at the bottom of a deep pool near low-water mark on the reefs below the University. Dr. Fleure recognised them as having occurred some ten years previously in crevices on the reefs below the Castle; that colony, however, disappeared, this being the first subsequent rediscovery. The colony consisted of an adult, on either side of which was situated a young individual, and from the irregular form and development of these I consider them to have recently originated by fission from the base of the large specimen.

The adult, although agreeing in the main with the plate and descriptions of Holdsworth and Gosse, showed some variation, chiefly in lack of distinctness and definition of the colouration, which had a somewhat blurred appearance.

Size when expanded: height of column, 5 mm.; diameter, 10 mm. Outline of base irregular. Column—smooth, with suckers on the upper portion. Faintly grooved longitudinally by the insertion of the mesenteries. Disk: convex during expansion, smooth. Mouth of fair size, raised, tumid, the throat somewhat ribbed.

Tentacles fairly numerous (about eighty-six), rather stout, tapering to the tip, held flexed outwards during expansion. Acontia fairly freely emitted.

Colours: Column, flesh colour, the suckers pale. Disk, semi-transparent umber, with a light yellowish area around the mouth; the yellow rays irregular; a cycle of twelve white irregularly shaped (not cordate) spots on the disk between the yellow rays. Gonidial radii white. Throat pink.

Tentacles, light umber, with three white or yellowish rings; the area between the second and third rings rich dark umber Slight dark lateral longitudinal streaks near the tentacle bases.

II. **Bunodes thallia**, Gosse.

I have been so fortunate as to discover a considerable number of this rare species, which varies in an interesting manner. It was originally described by Gosse, who obtained a colony at Lydstep, and he mentions four specimens subsequently discovered near Ilfracombe. G. Y. and A. F. Dixon have described a variety with white tentacles from the Ore Stone, near Torquay, and I have since taken both varieties in the neighbourhood of Padstow and Port Isaac, and a few small examples near Newquay. A few years ago I searched the original Lydstep locality in the hope of rediscovering this species, but without success, nor did I find it anywhere in that district. Gosse (p. 196) says: "About a dozen individuals of different sizes were associated in the dark angles and pools of a little insular rock exposed at spring-tide, that lies just off the cove called the Drock, near Lidstep. They were not troglodyte in habit, but adherent to the open rock, and therefore easily detached. The species is social; clustering together in groups, mutually pressing each other's sides." The Newquay specimens were small, typical in form and colouration, and were adhering to the under surfaces of stones at St. Columb Porth. Polzeath, between Padstow and Port Isaac, is the locality where I have found most specimens. A number of small specimens occurred attached to the lower side of stones which were more or less fixed in pools on the reefs. The greater number, many of considerable size, were found in situations very similar to those mentioned by Gosse; shallow pools, or low detached rocks surrounded by fine sand, which also lined the floor of all the pools and covered the anemones with the exception of the tentacles. So exactly did the grey and olive frecklings of these organs resemble the sand and byssal threads of the *Mytilus* colonies which abounded there, that only prolonged scrutiny and even feeling with the hands enabled me to ascertain the numbers present. The summit of the column was almost invariably covered with fragments of shell and sand attached by the suckers on prominent warts; and even when exposed the general hue of the column greatly resembled the olive-coloured algæ growing in the pools. All these specimens were normally coloured, the chief variation being the warts. In those individuals which lived affixed beneath stones the warts were frequently by no means strongly developed, and the whole column lighter in colour (in one instance dirty white). Those living exposed in the shallow pools possessed very conspicuous warts, especially toward the summit, where they were crowded, prominent, or even somewhat clavate.

An isolated colony of about a dozen specimens was discovered in Port Quin Bay, nearer Port Isaac. They were of the variety described by G. Y. and A. F. Dixon, from Torquay. Living in a long crack between two bare, rounded rocks in a pool about half-way up the reef, their opaque white tentacles (which are also slightly longer and more tapering in this variety) gave them the appearance of a colony of some species of *Sagartia*. The pattern of the disk showed some variation, but in most cases the raying was obscure, dull grey and umber predominating. The rays were more pronounced in the younger examples.

III. **The Actinian Fauna of Salcombe.**

Allen and Todd (3) enumerated eight species as found in the estuary. During a recent visit I examined the reefs on either side of the harbour mouth, with the result that six further species were discovered. This is partly owing to the fact that I collected rather further seaward than Allen and Todd, although several occurred within the area they examined.

The following are the additional species:—

1. *Sagartia miniata.* Rocks between South Sands and Splat Cove, a few specimens.
2. *S. nivea.* Reefs near Mill Bay, a few. Molt Point, one specimen.
3. *S. sphyrodeta.* Between South Sands and Splat Cove, a few.
4. *S. pallida.* Splat Cove, two on the under side of a stone in a pool on the reef. Normal size.
5. *Bunodes verrucosa.* Molt Point, a few. Mill Bay, not uncommon.
6. *Corynactis viridis.* Very abundant in sheltered positions on the reefs between Mill Bay and the Blackstone.

IV. **Actiniae collected between Bolt Tail and the River Avon, South Devon.**

The following observations were made during January and February, 1910. The species obtained were all littoral. The examination of the coast was as thorough as the weather would permit, but many days were lost through rough seas, etc. The Actinian fauna of the S. Devon coast is now fairly well known. A recent short search on reefs near Sidmouth (December 25th, 1909) produced only a solitary specimen of *A. equina;* E. J. Allen and R. A. Todd record that species and also *Anemonia sulcata* from the Orcombe Rocks at the mouth of the Exe. Many records from Teignmouth, Torquay and district, and Dartmouth are given by Gosse and others. Allen and Todd enumerate eight species from Salcombe; and the rich fauna of the Plymouth area is well known. My only excuse, therefore, for these notes is that they help to link up the Plymouth and Salcombe records as regards this group.

The following species were obtained: 1, *Actinia equina;* 2, *Anemonia sulcata* (*Anthea cereus*)*;* 3, *Cereus pedunculatus* (*S. bellis*)*;* 4, *Sagartia miniata;* 5, *Sagartia rosea;* 6, *Sagartia venusta;* 7, *Sagartia nivea;* 8, *Sagartia sphyrodeta;* 9, *Phellia murocincta;* 10, *Bunodes verrucosa* (*B. gemmacea*)*;* 11, *Tealia coriacea* (*T. crassicornis*).

The rocks in the area explored consist mainly of slates, grits, and conglomerate; there is some sand in the bays, and a large area of it at the River Avon. With the exception of Hope Cove, the whole region is very storm-swept.

The chief peculiarity of the district is that, with the exception of *A. equina*, *A. sulcata*, and *S. sphyrodeta* (occasionally in very sheltered angles and hollows), all the species have their habitat under fixed stones. It is practically useless to look for them under any stone which is easily moved, and usually it is a matter of careful observation to decide the most likely spots, to then remove some stone less firmly fixed than the rest, loosen and remove others, until finally the lower layers are reached; there, fixed and sheltered from stormy seas and moving stones, will be found such anemones as inhabit this coast. I ascribe this habit of life to the attrition of much coarse grit and shingle, which is to be found in almost every pool. A result of this enforced hidden existence is that the individuals are smaller than usual, and the pigmentation weaker. Particularly is this the case in the various species of *Sagartia*, tending in many instances to the obliteration or disappearance of typical markings, rendering a clear separation of the various species and varieties a matter of some difficulty.

Actinia equina. This species is neither very abundant nor large in the area examined, with the exception of the remarkable variety *fragacea.* This, though never common, occurs in most places and always of large size, and I can bear out all that Gosse states regarding this variety (see p. 177). The handsome colouration, large size, absence of the blue basal line, and in this area different distribution—(it is usually solitary and extends downward into the *Laminarian* zone)—renders it most conspicuous.

Anemonia sulcata is the only really abundant species on many reefs; colouration and size normal.

Sagartia miniata. One normally coloured, and one specimen of the variety *brunnea* (Gosse, p. 43)—both from beneath stones. Hope Cove.

Sagartia rosea. Ten specimens were obtained from a reef-pool between Thurlestone Sand and Hope Cove. In the pool, which was sheltered by a large rock, stood many slabs of slaty rock, on edge, and wedged together. By loosening one, all were in time examined, and the anemones discovered attached to the lower sides and edges of the stones. They were small and easily detached. The column elongate, when expanded almost pellucid white, in some slightly tinged with pink, the mesenteries showing very plainly; grooved, studded with numerous minute scattered whitish suckers to which adhered fragments of sand, etc., and in a few a brown mucous coat was present when first obtained.

Disk, semi-transparent white; mouth, rose-red; throat and stomodaeum, orange-red, showing through the integuments during expansion. Tentacles, rose, with a darker core when contracted, forty-eight to seventy in number.

These specimens manifested an intense dislike for light, and always crept under stones; at night the column was greatly lengthened, and then presented a most graceful pillar-like appearance, the rose-red throat and stomodaeum being very striking. They were all singularly insensitive, and it was a long time before I could procure the expulsion of acontia; finally one was extruded from the mouth.

Sagartia nivea. A few specimens from under stones, mostly of the variety *obscurata* of Gosse. From Hope Cove I obtained an abnormally developed example. Diameter 10 mm. expanded. The abnormality consisted of some sixty of the tentacles, comprising three-quarters of the circumference, remaining short and obtuse, and of the olivaceous hue of the summit of the column. The inner cycle about 2 mm. in length, the outer more like papillae than tentacles. The remaining thirty were normal in size and colouration, white, slender, and about 5 mm. long. The anemone had the appearance of never being properly expanded.

S. venusta. Normal in colour, but small.

S. sphyrodeta. Both varieties are present in the district, *candida* fairly abundant; *xanthopis* at Hope Cove under stones, among *Laminaria.*

Phellia murocincta. Two specimens, Warren Point, attached to the under side of stones, top of the Laminarian zone.

I can now extend the range of this species to four localities: Torquay (Gosse), Thurlestone, Zennor and Polzeath (these two in Cornwall). This would seem to indicate that the species is not so very rare, but when contracted within its covering it so resembles the many excrescences or fragments of debris so abundant under all stones in tide pools that probably it is often overlooked. A note on the Zennor specimens has already appeared in the Journal (September, 1907). I will only add that the Thurlestone examples agreed with them. The investing "coat" was easily detached, and did not adhere about the base; after its removal the anemones became restless and roamed until they obtained sufficient fragments to form a new covering, when they again became stationary. They only expanded at night, and when contracted and the covering was removed resembled, as Gosse observes, "a young *Sagartia viduata*." Tentacles 36. The Polzeath specimen was very small and only obtained by chance. Having observed several specimens of *Mytilus barbatus* mingled with *M. edulis* in a small cave, I detached them and put them in a collecting bottle full of water; on arriving home I observed the anemone fully expanded upon one of the *M. barbatus,* mingled with *Sycon coronata*, etc.

V. **Hoplangia Durotrix,** Gosse.

Originally mistaken by Gosse for *Phyllangia americana*, and subsequently described in *Actinologia Britannica*, p. 338, from specimens dredged in Weymouth Bay in 1858, when a colony of "from 50 to 100 specimens of this little coral, clustered in groups," was obtained, some of which came into his hands. The animal was not described, being too decomposed. Gosse states, however, that the discoverer spoke of it as resembling *Caryophyllia*, and "told me that he remarked numerous tentacles, but did not notice whether they were knobbed."

During a recent visit to Plymouth I examined a colony of more than thirty specimens, chipped off Wembury reef by W. Searle, 2nd September. 1909. The corals were of varying sizes, as Gosse says, "clustered in groups," on the stone. They agreed with the original Weymouth specimens. Diameter of largest unbroken individual, 5 mm.; height varied up to 10 mm.; outline varied, some being oval, others nearly circular. The colony had been killed partially expanded, and showed a considerable number of thick, obtuse tentacles, which do not appear to be knobbed. Searle tells me that the animals were colourless, or at any rate, he did not notice any colours like those of *Caryophyllia.*

LITERATURE.

1. 1860. Gosse, P. H. *Actinologia Britannica.*
2. Dixon, G. Y. and A. F., *Proc. Roy. Dub. Soc.*, vol. ii., N.S., Pt. 6, 1889.
3. 1900. Allen, E. J., and R. A. Todd, "The Fauna of Salcombe Estuary," *Journ. Mar. Biol. Assoc.*, vol. vi., No. 2.
4. 1902. Allen, E. J., and R. A. Todd, "The Fauna of the Exe," *Journ. Mar. Biol. Assoc.*, vol. v., No. 3.
5. Walton, C. L., "On *Phellia murocincta*, Gosse." *Journ. Mar. Biol. Assoc.*, vol. viii., No. 1, September.

Note on Abnormal Pigmentation of a Whiting infected by *Trematode larvæ.*

By

Prof. F. W. Gamble, F.R.S., and G. H. Drew, B.A., Beit Memorial Fellow.

In one of the tanks at the Plymouth Laboratory containing pipe-fish and sticklebacks, a whiting was found recently which exhibited black specks scattered over its pigmented areas and on the conjunctiva. The spots were fairly evenly distributed and averaged ·5 to ·1 mm. in diameter. Around each black point there was a clear unpigmented area.

Preparations showed that this abnormal colouration was due to a Trematode. Each black spot contained a cyst within which the parasite lay. The influence of the parasite has drawn towards the cyst all the neighbouring chromatophores, thus explaining the dense accumulation of pigment in each spot and the area of pallor surrounding it.

The Trematode is a species of *Holostomum*, probably *H. cuticola*, v. Nordmann; for that author described a similar infection in German Cyprinoids as long ago as 1832. The points of interest are the presence of this Trematode in British waters, the reaction of the chromatophores, and the migration of pigment-cells into the conjunctiva.

January 18, 1911.

ABSTRACTS OF MEMOIRS

RECORDING WORK DONE AT THE PLYMOUTH LABORATORY.

The Relation between Light and Pigment-formation in *Crenilabrus* and *Hippolyte.* By Prof. F. W. Gamble, F.R.S. (*Quart. Jour. Micros. Science*, Vol. LV, Pt. 3, 1910.)

The work on which this paper is based was carried out at Plymouth in 1908 and 1909. The two species on which the main results were investigated were *Crenilabrus melops* and *Hippolyte varians.* Backgrounds of weed and of painted glass were employed in order to test the influence of reflected light. Light-filters transmitting red and green respectively were used to determine the result of subjecting *Hippolyte* to diffused monochromatic light.

The following are the chief results:—

(1) *Crenilabrus.* The effect of light reflected from backgrounds of weeds and diluted with white light is different from the effect of light transmitted through the same weeds and not largely diluted with white light. In the former case the young animals generally assumed the tint of their surroundings; in the latter the dominant colouring was that complementary to the brightest part of the transmitted spectrum.

(2) *Hippolyte.* Any female of this variably coloured prawn throws larvæ which are constant in coloration with the exception of the broods of certain green parents. In other cases the colour (red) of the Zoeae varies in intensity at the time of hatching with the amount of red pigment in the female.

Green females throw one of three kinds of larvæ: (1) all red; (2) colourless; or (3) a mixture of red and colourless in the proportion of 3 to 1.

The red larval pigment develops in the absence of light. The origin of the yellow pigment has not been timed, but post-larval specimens (4–5 mm. long) if kept in darkness develop into brown specimens.

In pure green light similar (nearly colourless) specimens develop into crimson specimens. The red and yellow pigments disappear.

In pure red light the yellow pigment develops, and this together with a variable amount of diffuse blue colouring give a green tint, or a yellowish one. The colour of the food has apparently some influence upon the result.

On a red background and on a green background in white light *Hippolyte* become orange and green respectively.

The production of sympathetic colouring in the shallower coastal waters is explained as a background effect. The production of crimson *Hippolyte* (and possibly of reddish varieties of other marine animals) in deeper water is explained as due to diffused green light.

There is no evidence that the pigments of the algal food are the sources of the pigments in *Hippolyte varians*.

F. W. G.

The Reproduction and Early Development of *Laminaria digitata* and *Laminaria saccharina*. By G. H. Drew. *Ann. Bot.*, Vol. XXIV, No. XCIII., January, 1910, p. 177.

Laminaria digitata and *L. saccharina* are among the commonest seaweeds found on the coasts of the British Isles; they form the greater part of the "kelp" which is collected in some places for commercial purposes.

In the autumn and winter dark brown patches appear near the extremities of the broad flattened fronds, and in these the reproductive cells are formed. When ripe, small pieces of these reproductive areas were placed in a special culture solution (Allen and Nelson's modification of Miquel's solution), and it was found that an immense number of minute, free swimming cells were liberated. These cells each have two flagella, by means of which they are enabled to swim actively, and they show a tendency to move towards any source of light. Though all are exactly similar in appearance, yet these cells must be regarded as the sexual cells of the plant. After a time they fuse in pairs, lose their flagella, and settle to the bottom of the culture fluid. A series of changes then takes place resulting in the formation of a chain of cells possessing colouring matter, and apparently capable of absorbing nutrition, and of growth. This chain of cells can be considered as a separate plant, which though of an extremely rudimentary type, yet has an independent existence. Eventually any cell of the chain may give rise directly to a young *Laminaria* plant.

Thus in the life cycle of *Laminaria*, an alternation of generations occurs: the *Laminaria* plant represents the sexual phase, and the microscopic chain of cells above mentioned represents the asexual phase.

G. H. D.

Some Notes on Parasitic and Other Diseases of Fish. By G. H. Drew. *Parasitology*, Vol. II, No. 3, September, 1909, p. 193; second series, Vol. III, No. 1, April, 1910, p. 54.

An examination of a number of diseased fish was undertaken primarily with the object of finding cancerous growths. Many of the specimens were obtained by the s.s. *Huxley* in the North Sea.

Four cases of cancer were found resembling in appearance and structure malignant cancerous growths in man. Two of these originated in the pancreas of two specimens of plaice, and two in the livers of rainbow trout. There seems no reason to suppose that these growths are not in every way comparable to true carcinoma as found in man. One case of a superficial growth in a dog-fish was found, closely resembling the growths known as *endotheliomata*, which are generally included in the term "cancer." A number of cases of "benign" tumours were found (*fibromata*, *myxo-fibromata*, etc.), chiefly in plaice and salmon, and these also showed the closest resemblance to similar tumours in human beings. It thus seems probable that, whatever may be the cause of cancer and other tumours in man, the same cause may be operative in the production of similar growths in fish.

Several cases of disease due to sporozoon parasites were investigated, and two new species of sporozoa were described.

A number of cases of an affection of the swim-bladders of trout, resulting in the death of a large number of fish, were investigated. It was found that nematode worms made their way from the intestine into the swim-bladder by burrowing through the tissues, and carried bacteria with them, which set up an acute septic inflammation.

An outbreak of a contagious disease among fish in the Hertfordshire Colne was also investigated, and it was recognized as a recrudescence of the "salmon disease," in this case attacking fish of many different species. The specific bacteria were isolated, and also the white filamentous fungus, which grows freely on the lesions caused by the bacteria, was identified.

G. H. D.

Some Points in the Physiology of Lamellibranch Blood Corpuscles. By G. H. Drew. *Quar. Jour. Micro. Sci.*, Vol. LIV, Part 4, February, 1910, p. 605.

The Origin and Formation of Fibrous Tissue as a Reaction to Injury in *Pecten maximus*. By G. H. Drew and W. De Morgan. *Quar. Jour. Micro. Sci.*, Vol. LV, Part 3, September, 1910, p. 595.

THESE investigations were carried out as a necessary preliminary to further work of an experimental nature on the mode of origin of tumours. Most of the work was done on the common cockle and scallop.

The different sorts of corpuscles present in the blood were described, and it was shown that they were capable of ingesting, and so destroying, bacteria; thus protecting the animal from bacterial attacks. It was also shown that if the animal were wounded, so that any blood escaped, the corpuscles adhered to the injured surfaces and then sent out long, slender processes which would join up with similar processes from corpuscles on the other side of the wound. A network is thus formed in which other corpscules become entangled and so block up the opening of the wound. Finally, the protoplasmic strands forming the network contract, and so draw together the injured surfaces, which soon heal up.

The formation of fibrous tissue as a reaction to injury, and the consequent healing of wounds by "scar-tissue" formation, was also studied in detail. It was shown that any injurious foreign body which was implanted into the tissues of the animal was rapidly surrounded by an agglutinated layer of blood corpuscles, and that these were soon replaced by a dense mass of fibrous tissue. The foreign body thus becomes completely surrounded by a protective fibrous capsule, which, by shutting it off from the neighbouring tissues, tends to prevent its injurious action from spreading. It is perhaps an interesting point in the study of Evolution, to note that the process of "scar-tissue" formation, by which such animals as the scallops are enabled to recover from injuries, differs only in detail from the similar process which occurs in the highest types.

G. H. D.

Marine Biological Association of the United Kingdom.

Report of the Council, 1910-11.

The Council and Officers.

The usual four quarterly meetings of the Council have been held, at which the average attendance has been thirteen. The thanks of the Council are due to the Royal Society and to the Royal Astronomical Society for the use of their rooms for these meetings. A Committee of the Council has visited and inspected the Plymouth Laboratory.

The Plymouth Laboratory.

No considerable repairs or renewals of the engines, machinery, or equipment of the Laboratory have been found necessary during the year. The small room in the front on the ground floor of the east wing of the building has been fitted up as a Chemical Laboratory. Although the room is small it is a useful addition to the facilities of the Laboratory. The larger room at the back of the same wing has been specially fitted for work in experimental embryology. During the busy seasons of the year the demands for space for the different departments of our work are becoming very difficult to meet, and it was again necessary to hire a room at the Yacht Club below the Laboratory for the Easter Vacation Course.

The Boats.

Except for the addition of a small punt for harbour work the boats used are the same as last year. The steamer *Oithona* was laid up for the winter months, but is now again in commission, and is in sound working order.

The Staff.

Mr. F. J. Bridgman, Associate of the Royal College of Science, formerly demonstrator at the Imperial College of Science and Technology, South Kensington, has been appointed a Naturalist on the staff for the study of the biology of fishes, and Mr. J. H. Orton, B.Sc., of the same college, an Assistant-Naturalist for the study of invertebrates. The remaining members of the staff, Dr. E. J. Allen and Mr. D. J. Matthews, continue to occupy their former positions.

Occupation of Tables.

The following Naturalists have occupied tables at the Plymouth Laboratory during the year:—

K. H. BARNARD, B.A., Cambridge (Amphipoda).
L. R. CRAWSHAY, M.A., Plymouth (Fauna at Mid-Channel).
W. DE MORGAN, Plymouth (Hybridization of Echinus).
G. H. DREW, B.A., Plymouth (Tissue Transplantation in Pecten).
F. MARTIN DUNCAN, London (Photography of Marine Animals).
J. S. DUNKERLY, B.Sc., London (Parasitic Protozoa).
E. S. GOODRICH, F.R.S., Oxford (Embryology of Patella).
S. A. ARENDSEN HEIN, Utrecht (Eyes of Fishes).
HERBERT HENRY, M.D., Sheffield (Parasites of Blood of Fishes).
Prof. IWAJI IKEDA, Japan (Parasitic Protozoa).
J. W. JENKINSON, D.Sc., Oxford (Regeneration in Hydrozoa).
W. O. R. KING, M.A., Cambridge (Regeneration in Hydrozoa).
Miss M. V. LEBOUR, B.Sc., Leeds (Trematoda).
KEITH LUCAS, M.A., Cambridge (Physiology of Ciona).
J. F. MURPHY, Cork (Fishes).
G. E. NICHOLLS, B.Sc., London (Nervous System of Fishes).
R. C. PEARSON, B.A., Cambridge (General Zoology).
R. W. H. ROWE, B.Sc., London (Sponges).
J. T. SAUNDERS, B.A., Cambridge (Polychaeta).
C. SHEARER, M.A., Cambridge (Dinophilus).
GEOFFREY SMITH, M.A., Oxford (Blood of Carcinus).
T. H. TAYLOR, M.A., Leeds (Nematocysts of Coelenterata).
Miss GERARDA WIJNHOFF, Utrecht (Nemertina).

In addition to the above the Easter Vacation Course in Marine Biology was attended by seventeen students. This course was conducted again this year by Prof. Walter Garstang, of the University of Leeds, who gave the first course of the kind held at the Laboratory in 1895.

Dr. Cresswell Shearer, M.A., brought a class of six students from Cambridge for a practical course in Experimental Embryology.

A class of four students from the Imperial College of Science, South Kensington, attended at the Laboratory in July for a course of practical work in Marine Biology in continuation of the course conducted at the College in London by Dr. E. J. Allen in the previous spring.

General Work at the Plymouth Laboratory.

Work on the cultivation of plankton organisms and on the rearing of marine larvæ, which has been in progress for some years, has been continued and advanced. Several interesting forms of diatoms and algæ not previously obtained in persistent cultures have been isolated. Mr. W. De Morgan, who has worked in co-operation with Dr. C. Shearer, has reared a large number of hybrid larvæ obtained by intercrossing three species of *Echinus* in as many different ways as possible. It is hoped that these experiments will throw light upon some theoretical questions of considerable importance.

Mr. G. H. Drew, who was last year appointed a Beit Memorial Fellow, has carried out a number of successful experiments on the transplantation of tissues in invertebrate animals, which have an important bearing upon the cancer problem. He has also made a special study of certain diseases which occur in fishes.

Mr. Orton has been making a general study of the distribution of the invertebrate fauna of Plymouth, and has paid particular attention to the Echinodermata and Crustacea.

Fishery Investigations.

Owing to the transference of the North Sea Investigations and the staff connected therewith to the Board of Agriculture and Fisheries, and to the sale of the steamer *Huxley* which thus became necessary, it has not been possible during the past year to devote nearly so much attention as formerly to purely economic fishery problems. In future it is proposed to confine the economic work of the Association to special scientific problems of a fundamental character, which bear directly upon fishery investigations. At the same time it must be pointed out that the Plymouth Laboratory will still afford precisely such training as is required by men who may afterwards be employed in scientific investigation in the service of the Government, and that the general scientific work of the Association, though it may have no immediate economic value, is of such a character as to form an important part of the necessary foundation upon which the applied science of fisheries must in future be built.

Mr. Bridgman has commenced an investigation of the age and growth-rate of Plaice in the western part of the English Channel, in continuation of similar researches which were carried on by Dr. Wallace in connection with the North Sea Investigations. A considerable amount of material has already been collected, and this will, it is hoped, be largely added to as the year advances. Mr. Hefford's report on the embryonic and early larval stages of fishes obtained at Plymouth has been published in the Journal of the Association.

A further Blue Book has been published by His Majesty's Stationery Office dealing with the work done by the Association in connection with the International Investigations. This contains the Third Report on the subject prepared by the Association. The results contained in the separate memoirs were summarised in the Report of the Council for last year. A further Blue Book, which will contain the Fourth Report on the International Investigations, is now in the press. The thanks of the Association are due to the Board of Agriculture and Fisheries for allowing these reports to be completed by the members of the staff after the direction of their work had been transferred to the Board.

Published Memoirs.

The following papers, either wholly or in part the outcome of work done at the Laboratory, have been published elsewhere than in the official publications of the Association:—

Allen, E. J., and Nelson, E. W.—*On the Artificial Culture of Marine Plankton Organisms.* Quart. Journ. Micr. Sci., vol. 55, 1910, pp. 361–431.

Drew, G. H., and De Morgan, W.—*The Origin and Formation of Fibrous Tissue produced as a Reaction to Injury in Pecten maximus, as a Type of the Lamellibranchiata.* Quart. Journ. Micr. Sci., vol. 55, 1910, pp. 595–610.

Drew, G. H.—*Experimental Metaphasia. 1. The Formation of Columnar Ciliated Epithelium from Fibroblasts in Pecten.* Journal of Experimental Zoology, vol. 10, 1911, pp. 349–379.

Eliot, C.—*British Nudibranchiate Mollusca. By the late Joshua Alder and the late Albany Hancock.* Supplement. Ray Society.

Shearer, C.—*On the Anatomy of Histriobdella Homari.* Quart. Journ. Micr. Sci., vol. 55, 1910, pp. 287–360.

Gamble, F. W.—*The Relation between Light and Pigment-formation in Crenilabrus and Hippolyte.* Quart. Journ. Micr. Sci., vol. 55, 1910, pp. 541–584.

Hodgson, T. V.—*The Pycnogonida of Devonshire.* Trans. Devonshire Assocn. XLII, 1910, pp. 425–439.

The Library.

The thanks of the Association are due for the following books and current numbers of periodicals presented to the Library during the past year:—

Académie Imp. des Sciences de St. Pétersbourg. Bulletin.
American Museum of Natural History. Annual Report.
American Microscopical Society. Transactions.
American Philosophical Society. Proceedings.
Armstrong College. Calendar.
—— The Dove Marine Laboratory, Cullercoats.

Australian Museum. Memoirs.
—— Records.
—— Report.
Bergens Museum. Aarsberetning.
—— Aarbog.
—— An Account of the Crustacea of Norway, etc. By G. O. Sars.
—— The *Michael Sars* North Atlantic Deep Sea Expedition, 1910. List of Observing Stations and Particulars of the Apparatus employed.
Bermuda Biological Station for Research. Contributions.
Bernice Pauahi Bishop Museum, Honolulu. Occasional Papers.
Board of Agriculture and Fisheries. Annual Report of Proceedings under the Salmon and Freshwater Fisheries Acts.
—— Annual Report of Proceedings under Acts relating to Sea Fisheries.
—— Monthly Return of Sea Fisheries, England and Wales.
—— Report of Proceedings of Annual Meeting.
Board of Agriculture and Fisheries. Report on the Research Work of the Board in relation to the Plaice Fisheries of the North Sea.
—— Report of Proceedings at a Meeting of Representatives of Authorities under the Sea Fisheries Regulation Act, to consider a means to extend the scope and increase the effectiveness of the Annual Meetings.
British Association for the Advancement of Science. Report.
British Museum. Catalogue of the Books, Manuscripts, Maps, and Drawings in the British Museum (Natural History).
—— National Antarctic Expedition, 1901–4. Zoology and Botany.
—— Guide to the Crustacea, Arachnida, Onychophora, and Myriopoda exhibited in the Department of Zoology.
Brooklyn Institute of Arts and Sciences. Science Bulletin.
Bryn Mawr College. Monographs, Reprint Series.
Bulletin Scientifique de la France et de la Belgique.
Bureau of British Marine Biology. Contributions.
Cairo Zoological Gardens. Report.
California Academy of Sciences. Proceedings.
Carnegie Institution of Washington: Dept. of Experimental Evolution. Annual Report of the Director.
—— Dept. of Marine Biology. Annual Report of the Director.
—— Papers from the Tortugas Laboratory.
Ceylon Marine Biological Laboratory. Reports.
College of Science, Tokyo. Journal.
College voor de Zeevisscherijen. Verslag van den Staat der Nederlandsche Zeevisscherijen.
Colombo Museum. Director's Report.
—— Spolia Zeylanica.
Commissioners of Inland Fisheries, Rhode Island. Annual Report.
Conchological Society of Great Britain and Ireland. Journal of Conchology.
Conseil perm. internat. pour l'Exploration de la Mer. Bulletin Trimestriel des Résultats acquis pendant les Croisières Periodiques.
—— Publications de Circonstance.
—— Rapports et Procès-Verbaux des Réunions.
Cornwall Sea Fisheries Committee. Reports.
Cuerpo de Ingenieros de Minas del Peru. Boletin.

Dept. of Agriculture, etc., Ireland. Scientific Investigations.

—— Memoirs of the Geological Survey of Ireland on Rock Specimens dredged from the floor of the Atlantic off the Coast of Ireland, and their bearing on Submarine Geology.

Dept. of Commerce and Labor, U.S.A. Pamphlets.

—— Report of the Commissioner of Fisheries.

Dept. of Fisheries, New South Wales. Annual Report.

—— A Brief Review of the Fisheries of New South Wales: Present and Potential. By D. G. Stead.

Dept. of Marine and Fisheries, Canada. Annual Report.

Dept. of Trade and Customs, Melbourne. Report by Director of Fisheries on Fishing Experiments carried out by the F.I.S. *Endeavour*.

Deutscher Fischerei-Verein. Zeitschrift für Fischerei.

Deutscher Seefischerei-Verein. Mitteilungen.

Dominion Museum. Hand List of New Zealand Lepidoptera.

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Giard, A., and Cépède, C. Sur la Ponte de la Morue dans le Sud de la Mer du Nord.

Gilson, G. Exploration de la Mer sur les côtes de Belgique.

—— Études sur l'Outillage de la Pêche. Le Chalut à Fers Déclinants. Type nouveau d' Armature à gaule.

Goodey, T. Vestiges of the Thyroid in *Chlamydoselachus anguineus*, *Scyllium catulus*, and *Scyllium canicula.*

—— A Contribution to the Skeletal Anatomy of the Frilled Shark, *Chlamydoselachus anguineus* Gar.

Haecker, V. Pelagische Polychätenlarven. 2. Zur Biologie der Atlantischen Hochseeformen.

—— Über Chromosomen-und Sporenbildung bei Radiolarien.

—— Zur Statik und Entwicklung des Coelographidenskelettes.

—— Altertümliche Sphärellarien und Cyrtellarién aus grossen Meerestiefen.

Hansen, H. J. Pycnogonider og Malacostrake Krebsdyr fra Premierlieutenant Ryder's Expedition til Ostgrönland 1891–2.

—— *Echinocheres globosus*, n. gen., n. sp., a Copepod parasitic in spines of an Echinothurid.

—— Revideret Fortegnelse over Danmarks Marine Arter af Isopoda Tanaidacea Cumacea, Mysidacea og Euphausiacea.

—— Résultats du Voyage du S.Y. *Belgica.* Schizopoda and Cumacea.

Hartlaub, C., Croisière Océanographique accomplie à bord de la *Belgica* dans la Mer du Grönland 1905. Méduses.

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Hartmeyer, R. Zur Terminologie des Ascidien.

—— Pyura echinata (L.) oder Microcosmus echinatus (L.)

—— Die Ascidien der *Danmark* Expedition.

Herdman, W. A. A Comparison of the Summer Plankton on the West Coast of Scotland with that in the Irish Sea.

Hodgson, T. V. The Pycnogonida of Devonshire.

Hogue, M. J. Über die Wirkung der Centrifugalkraft auf die Eier von *Ascaris megalocephala.*

Horst, R. *Palaegyge Buitendijki*, n. sp. parasitic on *Palaemon carcinus* Fabr. from Java.

—— On the Genus Chloeia with some new species from the Malay Archipelago, partly collected by the Siboga-Expedition.

Janet, C. Sur la Morphologie des Membranes basales de l'Insecte.
—— Sur la Parthénogénèse arrhénotoque de la Formi ouvrière.
—— Sur un Nematode qui se développe dans la tête de la *Formica fusca.*
—— Note sur la Phylogénèse de lInsecte.
—— Sur la Morphologie de l'Insecte.
—— Sur l'Ontogénèse de l'Insecte.
Jennings, H. S. A List of the Rotatoria of the Great Lakes and of some of the Inland Lakes of Michigan.
—— Comparative Psychology.
—— What Conditions induce Conjugation in Paramecium?
—— Experimental Evidence on the Effectiveness of Selection.
—— The Interpretation of the Behavior of the Lower Organisms.
—— Synopses of North-American Invertebrates. XVII. The Rotatoria.
—— Tropisms.
—— The Basis for Taxis and Certain Other Terms in the Behavior of Infusoria.
—— Behavior of the Starfish *Asterias forreri* de Loriol.
—— On the Significance of the Spiral Swimming of Organisms.
—— Artificial Imitations of Protoplasmic Activities, and Methods of Demonstrating them.
—— The Behavior of Unicellular Organisms.
—— Studies on Reactions to Stimuli in Unicellular Organisms. V. On the Movements and Motor Reflexes of the Flagellata and Ciliata.
Jennings, H. S., and Hargitt, G. T. Characteristics of the Diverse Races of Paramecium.
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Jennings, H. S., and Moore, E. M. Studies on Reactions to Stimuli in Unicellular Organisms. VIII. On the Reactions of Infusoria to Carbonic and other Acids, with Especial Reference to the causes of the gatherings spontaneously formed.
Johnstone, J. Routine Methods of Shellfish Examination with Reference to Sewage Pollution.
Juday, C. Some European Biological Stations.
Kerr, Graham. Marine Biology and the Firth of Clyde.
Kofoid, C. A. The Biological Stations of Europe.
—— A Revision of the Genus *Ceratocorys*, based on Skeletal Morphology.
—— A great Marine Museum.
—— Significance of Certain Forms of Asymmetry of the Dinoflagellata.
—— The Faunal Relations of the Dinoflagellata of the San Diego Region.
Kofoid, C. A., and Watson, E. E. On the Orientation of Gyrocotyle and of the Cestode Strobila.
Krumbach, T. Notizen über die Fauna der Adria bei Rovigno. I. Grundlinien zur Geophysik von Rovigno.
Lee, A. B. La réduction numérique et la conjugaison des chromosomes chez l'escargot.
Legendre, R. Traces fossiles d'autotomie.
—— Variations physico-chimiques de l'eau de mer littorale à Concarneau.
—— Variations de température de densité et de teneur en oxygène de l'eau de mer littorale à Concarneau et à Arcachon.

Legendre, R. Recherches sur les variations de température, de densité et de teneur en oxygène de l'eau de la Côte à Arcachon.

—— La Pêche à marée basse.

Linton, E. On a new Rhabdocoele commensal with *Modiolus plicatulus.*

—— Notes on the Flesh Parasites of Marine Food Fishes.

Loeb, J. On the Chemical Character of the Process of Fertilization and its Bearing upon the Theory of Life Phenomena.

—— Chemische Konstitution und physiologische Wirksamkeit der Sauren.

—— Chemische Konstitution und physiologische Wirksamkeit von Alkoholen und Saüren. II.

—— Biochemie der Zelle. III. Ueber physiologische Ionenwirkungen, insbesondere die Bedeutung der Na-, Ca- und K-Ionen.

—— Über die chemischen Bedingungen für die Entstehung eineiiger Zwillinge beim Seeigel.

—— Die Bedeutung der Tropismen für die Psychologie.

—— Weitere Versuche über die Entwicklungserregung des Seeigeleies durch das Blutserum von Säugethieren.

—— Ueber die Hervorrufung der Membranbildung und Entwicklung beim Seeigelei durch das Blutserum von Kaninchen und durch cytolytische Stoffe

—— Ueber den Temperatur-koeffizienten für die Lebensdauer kaltblütiger Thiere und über die Ursache des natürlichen Todes.

—— Ueber die Entwicklungserregung unbefruchteter Annelideneier (Polynoë) mittelst Saponin und Solanin.

—— Über die osmotischen Eigenschaften und die Entstehung der Befruchtungsmembran beim Seeigelei.

—— Über Heliotropismus und die periodischen Tiefenbewegungen pelagischer Tiere.

—— Ueber die Natur der Bastardlarve zwischen dem Echinodermenei (*Strongylocentrotus franciscanus*) und Molluskensamen (*Chlorostoma funebrale*).

—— Über den Unterschied zwischen isosmotischen und isotonischen Lösungen bei der künstlichen Parthenogenese.

—— Über die chemischen Bedingungen für die Entstehung eineiiger Zwillinge beim Seeigel.

—— Weitere Versuche über die Nothwendigkeit von freiem Sauerstoff für die entwicklungserregende Wirkung hypertonischer Lösungen.

—— Ueber die allgemeinen Methoden der künstlichen Parthenogenese.

—— Über die superposition von künstlichen Parthenogenese und Samenbefruchtung in demselben Ei.

—— Zur Analyse der osmotischen Entwicklungserregung unbefruchteter Seeigeleier.

—— Weitere Beobachtungen über den Einfluss der Befruchtung und der Zahl der Zellkerne auf die Saürebildung im Ei.

—— Weitere Versuche über heterogene Hybridisation bei Echinodermen.

—— Ueber den Einfluss der Hydroxyl- und Wasserstoffionen auf die Regeneration und das Wachsthum der Tubularien.

—— Ueber dynamische Umstände, welche bei der Bestimmung der Morphologischen Polarität der Organismen mitwirken.

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—— Maturation, Natural Death and the Prolongation of the Life of unfertilized Starfish Eggs (*Asterias Forbesii*) and their significance for the theory of Fertilization.

—— Studies on the Physiological Effects of the Valency and possibly the Electrical Charges of Ions. I. The Toxic and Antitoxic Effects of Ions as a Function of their Valency and possibly their Electrical Charge.

—— Experiments on Artificial Parthenogenesis in Annelids (Chaetopterus) and the nature of the process of Fertilization.

—— Ueber die Bedeutung der Ca- und K-Ionen für die Herzthatigkeit.

—— Ueber den Einfluss der Werthigkeit und möglicher Weise der elektrischen Ladung von Ionen auf ihre antitoxische Wirkung.

—— Über die angebliche gegenseitige Beeinflussung der Furchungszellen und die Entstehung der Blastula.

—— Ueber die physiologische Wirkung von Alkalien und Säuren in starker Verdünnung.

—— Einige Bemerkungen über den Begriff, die Geschichte und Literatur der allgemeinen Physiologie.

—— Zur Theorie der physiologischen Licht- und Schwerkraft-wirkungen.

—— Zur Theorie des Galvanotropismus III. Ueber die polare Erregung der Hautdrüsen von Amblystoma durch den constanten Strom.

—— Zur Physiologie und Psychologie der Actinien.

—— Beiträge zur Entwickelungsmechanik der aus einem Ei entstehenden Doppelbildungen.

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McIntosh, W. C. Note on Irish Annelids in the Museum of Science and Art, Dublin.

—— Notes from the Gatty Marine Laboratory.

Man, J. G. de. Beiträge zur Kenntnis der in dem weissen Schleimfluss der Eichen lebenden Anguilluliden, nebst Untersuchungen über den Bau des Essigälchens und der Gattung *Anguillula* Ehrb.

—— Über eine neue Art der Gattung Arete, Stimps.

Marceau, F. Sur les fibres musculairs dites doublement striées obliquement.

—— Note sur la structure du cœur chez les Céphalopodes.

—— Recherches sur la physiologie et en particulier sur les lois de la production de travail mécanique par les muscles adducteurs des Acéphales.

—— Recherches sur la structure des muscles du manteau des Céphalopodes en rapport avec leur mode de contraction.

—— Note complémentaire sur la structure du manteau des Céphalopodes en rapport avec leur mode de contraction.

—— Recherches sur le mouvement de bascule des valves de certains Acéphales pendant leur ouverture et leur fermeture et ses conséquences morphogéniques.

Masterman, A. T. On a possible case of Mimicry in the Common Sole.
—— Report on the Later Stages of the Pleuronectidae.
—— Second Report on the Later Stages of the Pleuronectidae (for 1909).
Mayer, A. G. The Converse Relation between Ciliary and Neuro-Muscular Movements.
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—— Alexander Agassiz, 1835–1910.
Mortensen, Th. *Tjalfiella tristoma*, n. g., n. sp. A sessile Ctenophore from Greenland.
—— Echinological Notes.
Needham, J. G. Practical Nomenclature.
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—— On *Gasterostomum tergestinum* Stossich.
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Norman, W. W. Do the Reactions of the Lower Animals against injury indicate pain sensations? With Additional Note by J. Loeb.
Perrier, E., and Anthony, R. Organisation d'une étude générale du Plankton de la Baie de la Hougue.
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—— Des réactions de l'*Actinia equina* à la désoxygénation progressive du milieu.
Police, G. La Pesca nel Golfo di Napoli. I. La Pesca con le nasse.
Popta, C. M. L. Étude sur la vessie aérienne des Poissons. Sa fonction.
Pütter, A. Der Stoffwechsel der Aktinien.
—— Die Ernährung der Wassertiere durch gelöste organische Verbindungen.
Rathbun, M. J. Decapod Crustaceans collected in Dutch East India and elsewhere by Mr. Thomas Barbour in 1906–1907.
—— The Stalk-eyed Crustacea of Peru and the adjacent coast.
—— The Danish Expedition to Siam, 1899–1900. V. Brachyura.
Redeke, H. C. Temperatuur en Zoutgehalte van het Zeewater bij drie Nederlandsche Lichtschepen en in het Marsdiep, 1906–1908.
—— Über den Sprott und die Sprottfischerei in Holland.
Regan, C. Tate. A Synopsis of the Sharks of the Family Cestraciontidae.
—— A Synopsis of the Sharks of the Family Scyliorhinidae.
—— A Synopsis of the Sharks of the Family Squalidae.
—— A Revision of the Sharks of the Family *Orectobobidae.*
—— Report on the Marine Fishes collected by Mr. J. Stanley Gardiner in the Indian Ocean.
—— A Preliminary Revision of the Irish Char.
—— A Revision of the British and Irish Fishes of the Genus Coregonus.
—— A Revision of the Fishes of the Genus Elops.
—— The Char (*Salvelinus*) of Great Britain.
—— The Species of Three-spined Sticklebacks.
—— Descriptions of new Marine Fishes from Australia and the Pacific.
—— On Colour-changes in Fishes.
—— A Collection of Fishes made by Dr. C. W. Andrews, F.R.S., at Christmas Island.
—— The Anatomy and Classification of the Teleostean Fishes of the Order Zeomorphi.

Regan, C. Tate. The Origin and Evolution of the Teleostean Fishes of the Order Heterosomata.
—— On the Caudal Fin of the Clupeidae, and on the Teleostean Urostyle.
—— The Origin of the Chimaeroid Fishes.
—— Notes on the Classification of the Teleostean Fishes.
—— A Synopsis of the Marsipobranchs of the Order Hyperoartii.
—— On the Systematic Position of *Macristium chavesi*.
Richters, F. Nordische Tardigraden.
—— Zwei neue Echiniscus-Arten.
—— Marine Tardigraden.
—— *Cladonema radiatum* bei Helgoland.
—— Islandische Tardigraden.
—— Bunonema.
—— Wiederbelebungsversuche mit Tardigraden.
—— Antarktische Tardigraden.
—— Vorläufiger Bericht über die antarktische Moosfauna.
—— Rotatoria, Tardigrada und andere Moosbewohner.
—— Beitrag zur Kenntnis der Moosfauna Australiens und der Inseln des Pazifischen Ozeans.
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—— Tardigraden-Studien.
—— Meer-Bärtierchen.
—— Tardigraden aus den Karpathen.
Schaeffer, A. A. Selection of Food in *Stentor caerulens* (Ehr.).
Scharff, R. F. The Irish Whale Fishery.
Shaw, H. O. N. *Cypraea* and *Trivia*.
—— Anatomical Differences between *Cypraea* and *Trivia*.
—— Notes on the References to Certain Groups, etc., used in the Classification of Mollusca.
Schaxel, J. Das Zusammenwirken der Zellbestandteile bei der Eireifung, Furchung und ersten Organbildung der Echinodermen.
Shearer, C. On the Development and Structure of the Trochophore of *Hydroides uncinatus* (Eupomatus).
Stephenson, J. On some Littoral Oligochaeta of the Clyde.
Sherborn, C. D., and Shaw, H. O. N. Sowerby's "Conchological Illustrations" and Gray's "Descriptive Catalogue of Shells."
Shipley, A. E. Grouse Disease.
—— William Henry Dallinger, 1842–1909.
—— "Foreword."
—— Report upon two small Collections of Pentastomids with the Description of a New Species of "Porocephalus."
Sterzinger, I. Über die Spirorbis-Arten der Nordlichen Adria.
Stuckey, F. G. A., and Walton, C. L. Notes on a Collection of Sea-anemones.
Sumner, F. B. An Experimental Study of Somatic Modifications and their reappearance in the offspring.
—— An Intensive Study of the Fauna and Flora of a restricted area of sea bottom.
Sun, A. Über einen Parasiten aus der Körperhöhle von *Ptychodera minuta*.
Sund, O., and Koefoed, E. Underskelser over Brislingen i Norske farvand vaesentlig paa Grundlag av "Michael Sars's" Togt 1908, med Tabellen over foreksomst af Egg og Yngel fra "Michael Sars's" Togt 1908.

Thomson, J. S. The Alcyonaria of the Cape of Good Hope and Natal. Alcyonacea.

Tracy, H. C. The Fishes of Rhode Island. V. The Flat Fishes. VI. A Description of two young specimens of Squeteague (*Cynoscion regalis*), with Notes on the Rate of their Growth.

—— Annotated List of Fishes known to inhabit the waters of Rhode Island.

Treadwell, A. L. *Haplosyllis cephalata* as an Ectoparasite.

—— Polychaetous Annelids from the Dry Tortugas, Florida.

Trybom, F. Svenska rödspättemarkningar 1909, med tillägg från äldre märkningar.

Vayssière, A. Sur un nouveau genre de la famille des Tritoniadés.

—— Sur les Tectibranches du Golfe de Marseille.

—— Sur le dimorphisme sexuel des Nautiles.

—— Sur un nouveau *Temnocephala*, parasite de l'*Astacoides madagascariensis*.

—— Étude anatomique sur le *Coléophysis* (*Utriculus*) *truncatula*, Brug.

—— Considerations sur les differences qui existent entre la faune des Opistobranches des côtes océaniques de la France et celles de nos côtes mediterranéennes.

—— Recherches zoologiques et anatomiques sur les Mollusques Opistobranches du Golfe de Marseille. III. Nudibranches.

—— Sur les Opisthobranches recueillis en 1883 par l'expédition du Talisman.

—— Etude Zoologique de l'*Archidoris stellifera* H. von Ihering.

—— Observations zoologiques et anatomiques sur l'*Ammonicera* nouveau genre de Gastéropode Prosobranche.

—— Notice sur les Travaux scientifiques.

Vejdovský, F. Neue Untersuchungen über die Reifung und Befruchtung.

Viguier, C. Nouvelles études sur le Plankton de la Baie d'Alger.

Vles, F. Les notions de Martin Lister (1694) sur la locomotion des Gasté-ropodes.

—— Sur la valeur des stries musculaires au point de vue spectrographique.

—— Sur les bruits émis par des *Helix* pendant leur progression.

—— Monographie sommaire de la Mye (*Mya arenaria* Linné 1767).

—— Sur un micromètre oculaire à vernier intérieur.

Walker, A. O. Notes on Amphipoda.

—— Marine Amphipods from Peru.

Whitehouse, R. H. Some Remarks on the Teleostean Caudal Fin.

—— The Caudal Fin of the Teleostomi.

Wijnhoff, G. Die Gattung Cephalothrix und ihre Bedeutung für die Systematik der Nemertinen.

—— Verslag aan Zijne Excellentie den Minister van Binnenlandsche Zaken, aangaande onderzoeking verricht door Gerarda Wijnhoff, phil. nat. doct. van 3] Mei—13 Juni en 6 Juli—14 September 1910 in het Zoologisch Laboratorium van de Marine Biological Association te Plymouth.

Willey, A. Convergence in Evolution.

Winiwarter, H. von. Nachtrag zu meiner Arbeit über Oogenese der Säugetiere.

—— Das interstitielle Gewebe der Menschlichen Ovarien.

Winiwarter, H. von, and Sainmont, G. Erfahrungen über die Flemmingsche Dreifärbung.

Woodruff, L. L. Two Thousand Generations of Paramecium.

Woodruff, L. L., and Bunzel, H. H. The Relative Toxicity of various Salts and Acids towards Paramecium.

Donations and Receipts.

The receipts for the year include the grants from His Majesty's Treasury (£1000) and the Worshipful Company of Fishmongers (£400, of which £100 had been paid in advance), Special Donations (£169), Annual Subscriptions (£156), Rent of Tables in the Laboratory (£75), Sale of Specimens (£505), Admission to Tank Room (£105)

The following is a list of the Special Donations :—

	£	s.	d.
G. P. Bidder, Esq.	100	0	0
Professor G. C. Bourne, F.R.S.	3	19	0
Cambridge University—Zoological Dept.	25	0	0
F. Martin Duncan, Esq.	1	1	0
G. H. Fox, Esq.		10	6
London University	25	0	0
University College, London	5	0	0
Per the Director	8	6	8
	£168	17	2

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1911–12 :—

President.

Sir E. RAY LANKESTER, K.C.B., LL.D., F.R.S.

Vice-Presidents.

The Duke of ABERCORN, K.G., C.B.
The Duke of BEDFORD, K.G.
The Earl of ST. GERMANS.
The Earl of DUCIE, F.R.S.
The Earl of STRADBROKE, C.V.O., C.B.
Lord AVEBURY, F.R.S.
Lord WALSINGHAM, F.R.S.
The Right Hon. A. J. BALFOUR, M.P., F.R.S.
The Right Hon. JOSEPH CHAMBERLAIN, M.P.
The Right Hon. AUSTEN CHAMBERLAIN, M.P.
W. W. ASTOR, Esq., M.P.
G. A. BOULENGER, Esq., F.R.S.
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A. R. STEEL-MAITLAND, Esq., M.P.
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Geoffrey W. Smith, Esq.
Prof. D'Arcy W. Thompson, C.B.

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A. E. Shipley, Esq., D.Sc., F.R.S.

Hon. Treasurer.

J. A. Travers, Esq., Tortington, Arundel.

Hon. Secretary.

E. J. Allen, Esq., D.Sc., The Laboratory, Citadel Hill, Plymouth.

The following Governors are also members of the Council:—

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THE PRIME WARDEN OF THE FISHMONGERS' COMPY.
Sir Richard Martin, Bart. (Fishmongers' Company).
W. L. Birch, Esq. (Fishmongers' Company).
Prof. G. C. Bourne, D.Sc., F.R.S. (Oxford University).
A. E. Shipley, Esq., D.Sc., F.R.S. (Cambridge University).
Prof. W. A. Herdman, D.Sc., F.R.S. (British Association).

Dr. *Statement of Receipts and Payments for*

	£	s.	d.	£	s.	d.
To Balance from last year, viz. :—						
Cash at Bank	1,033	12	2			
Cash in hand	9	17	8			
	1,043	9	10			
Less Bank Loan	300	0	0	743	9	10
,, Current Income :—						
H.M. Treasury	1,000	0	0			
The Worshipful Company of Fishmongers: Balance of Grant	300	0	0			
Annual Subscriptions	156	3	0			
Composition Fee	15	15	0			
Rent of Tables	75	9	3	1,547	7	3
,, Extraordinary Receipts :—						
Donations, per Report				168	17	2
				£2,459	14	3

Examined and found correct.

(Signed) N. E. WATERHOUSE, F.C.A. W. T. CALMAN.
WYNDHAM BIRCH. L. W. BYRNE.

27*th June*, 1911.

the Year ending 31*st May*, 1911. Cr.

				£	s.	d.	£	s.	d.
By Current Expenditure :—									
Salaries and Wages—									
Director				200	0	0			
Assistant Director				26	5	0			
Hydrographer				143	15	0			
Naturalist				54	13	0			
Assistant Naturalists				108	6	8			
Salaries and Wages, and Compensation paid				674	17	10			
				1,207	17	6			
Less Compensation recovered from Employers' Liability Assurance Corporation				45	1	3	1,162	16	3
Travelling Expenses							40	4	3
Library				137	11	11			
Less Duplicates sold				3	18	2	133	13	9
Lecture Expenses							10	3	0
Journal, Vol. IX, Part I				44	17	0			
Less Sales				17	15	11	27	1	1
Buildings and Public Tank Room—									
Gas, Water, and Coal				116	0	4			
Stocking Tanks and Feeding				34	9	1			
Maintenance and Renewals				193	2	6			
Rent, Rates, Taxes, and Insurance				55	18	10			
				399	10	9			
Less Admission to Tank Room				105	2	6	294	8	3
Laboratory, Boats, and Sundry Expenses—									
Glass, Apparatus, and Chemicals	199	11	1						
Less Sales	111	4	0	88	7	1			
Purchase of Specimens				56	10	10			
Maintenance and Renewals of Boats, Nets, Gear, etc.	368	11	3						
Less Sales, including equipment for Captain Scott's Antarctic Expedition	229	7	5	139	3	10			
Insurance of s.s. *Oithona*				18	17	7			
Coal and Water for Steamer				76	15	9			
Stationery, Office Expenses, Printing, etc.				171	13	8			
				551	8	9			
Less Sale of Specimens	505	4	11						
Expenses of Salmon Experiment undertaken on behalf of the Duke of Bedford, refunded	29	16	11	535	1	10	16	6	11
By Bank Interest							1	18	2
By the Trustees of the "Ray Lankester Fund"— By Deed dated 11th May, 1911, the Trusts regulating this Fund were declared, and the above sum has been invested in the names of Trustees nominated by Mr. G. P. Bidder. (See note to accounts for the year ending 31st May, 1910.)							750	7	6
By Balance :—									
Cash at Bank				316	0	4			
Cash in hand				6	14	9			
				322	15	1			
Less Bank Loan				300	0	0	22	15	1
This Balance is apportioned as follows :—									
Repairs and Renewals	200	0	0						
Less General Account overdrawn	177	4	11						
	£22	15	1						
							£2,459	14	3

Marine Biological Association of the United Kingdom.

LIST
OF
Governors, Founders, and Members.

1ST OCTOBER, 1911.

* Member of Council. † Vice-President. ‡ President.

Ann. signifies that the Member is liable to an Annual Subscription of One Guinea.

C. signifies that he has paid a Composition Fee of Fifteen Guineas in lieu of Annual Subscription.

I.—Governors.

The British Association for the Advancement of Science, *Burlington House, W.*	£500
The University of Oxford	£500
The University of Cambridge	£500
The Worshipful Company of Clothworkers, 41, *Mincing Lane, E.C.*	£500
The Worshipful Company of Fishmongers, *London Bridge, E.C.*	£9705
Bayly, Robert (the late)	£1000
Bayly, John (the late)	£600
Thomasson, J. P. (the late)	£970
G. P. Bidder, Esq., *Cavendish Corner, Cambridge*	£1400

II.—Founders.

1884	The Corporation of the City of London	£210
1884	The Worshipful Company of Mercers, *Mercers' Hall, Cheapside*	£341 5*s.*
1884	The Worshipful Company of Goldsmiths, *Goldsmiths' Hall, E.C.*	£100
1884	The Royal Microscopical Society, 20, *Hanover Square, W.*	£100
1884	The Royal Society, *Burlington House, Piccadilly, W.*	£350
1884	The Zoological Society, *Regent's Park, London, N.W.*	£100
1884	Bulteel, Thos. (the late)	£100
1884	Burdett-Coutts, W. L. A. Bartlett, 1, *Stratton Street, Piccadilly, W.*	£100
1884	Crisp, Sir Frank, Treas. Linn. Soc., 17, *Throgmorton Avenue, E.C.*	£100
1884	Daubeny, Captain Giles A., *The Vicarage, Tottington, Bury, Lancs.*	£100
1884	Eddy, J. Ray, *The Grange, Carleton, Skipton*	£100
1884	Gassiott, John P. (the late)	£100

‡1884	Lankester, Sir E. Ray, K.C.B., F.R.S., 29, *Thurloe Place, South Kensington, S.W.*	£100
1884	The Rt. Hon. Lord Masham (the late)	£100
1884	Moseley, Prof. H. N., F.R.S. (the late)	£100
†1884	The Rt. Hon. Lord Avebury, F.R.S., *High Elms, Bromley, Kent*	£100
1884	Poulton, Prof. Edward B., M.A., F.R.S., *Wykeham House, Oxford*	£100
1884	Romanes, G. J., LL.D., F.R.S. (the late)	£100
1884	Worthington, James (the late)	£100
1885	Derby, the late Earl of	£100
1887	Weldon, Prof. W. F. R., F.R.S. (the late)	£100
1888	Bury, Henry, M.A., *Mayfield House, Farnham, Surrey*	£100
1888	The Worshipful Company of Drapers, *Drapers' Hall, E.C.*	£315
1889	The Worshipful Company of Grocers, *Poultry, E.C.*	£120
1889	Thompson, Sir Henry, Bart. (the late)	£110
1889	Revelstoke, The late Lord	£100
1890	Riches, T. H., B.A., *Kitwells, Shenley, Herts*	£230
1902	Gurney, Robert, *Ingham Old Hall, Stalham, Norfolk*	£105
1909	Harding, Colonel W., *The Hall, Madingley, Cambridge*	£100
†1910	Murray, Sir John, K.C.B., F.R.S., *Challenger Lodge, Wardie, Edinburgh*	£100

III.—Members.

1897	Adams, W. R., 16, *Milestone Road, Cintra Park, Upper Norwood, London*	Ann.
1900	Aders, W. M., 3, *Hall Road, London, N.W.*	Ann.
1884	Alger, W. H., 8, *The Esplanade, Plymouth*	C.
*1895	Allen, E. J., D.Sc., *The Laboratory, Plymouth*	Ann.
*1889	Alward, G. L., *Enfield Villa, Humberstone Avenue, Waltham, Grimsby*	Ann.
1910	Ashworth, J. H., D.Sc., *The University, Edinburgh*	Ann.
1892	Assheton, R., M.A., *Riversdale, Grantchester, Cambridge*	£20
†1911	Astor, W. W., M.P., 4, *St. James's Square, London, W.*	C.
1910	Atkinson, G. T., 43, *Parliament Street, London, S.W.*	Ann.
1902	Baker, R. J., 3, *Ash Villas, Collings Park, Mannamead, Plymouth*	Ann.
1884	Balfour, Prof. Bayley, F.R.S., *Royal Botanic Gardens, Edinburgh*	C.
1908	Ballard, Edward, *Greenfield, Hoole Village, Chester*	Ann.
1884	Bayliss, W. Maddock, D.Sc., F.R.S., *St. Cuthberts, West Heath Road, Hampstead*	Ann.
1884	Bayly, Miss, *Seven Trees, Plymouth*	£50
1884	Bayly, Miss Anna, *Seven Trees, Plymouth*	£50
1884	Beaumont, W. I., B.A., *The Laboratory, Plymouth*	Ann.
1885	Beck, Conrad, 68, *Cornhill, E.C.*	C.
1884	Beddington, Alfred H., 8, *Cornwall Terrace, Regent's Park, N.W.*	C.
†1907	Bedford, His Grace the Duke of, K.G., *Endsleigh, Tavistock*	C. & Ann. £10 10s.
1903	Bidder, H. F., 10, *Queen's Gate Gardens, London, S.W.*	Ann.
1910	Bidder, Mrs. M. G., *Cavendish Corner, Cambridge*	Ann.
1910	Bloomer, H. H., 35, *Paradise Street, Birmingham*	Ann.
1910	Borley, J. O., M.A., 43, *Parliament Street, London, S.W.*	Ann.
*1884	Bourne, Prof. Gilbert C., M.A., F.R.S., *Savile House, Mansfield Road, Oxford*	Ann.

1910	Bowkett, Sidney, *Claygate, Surrey*	Ann.
1898	Bowles, Col. Henry, *Forty Hall, Enfield*	Ann.
1910	Bradford, J. Rose, M.D., D.Sc., F.R.S., 8, *Manchester Square, London, W.*	Ann.
1910	Bridgman, F. J., *The Laboratory, Plymouth*	Ann.
1902	Brighton Public Library (Henry D. Roberts, Chief Librarian)	Ann.
1886	Brooksbank, Mrs. M., *Leigh Place, Godstone, Surrey*	*C.*
1884	Brown, Arthur W. W., 62, *Carlisle Mansions, Carlisle Place, London, S.W.*	*C.*
1910	Brown, F. J., 10, *Belmont Road, Ilfracombe*	Ann.
1893	Browne, Edward T., B.A., *Anglefield, Berkhamsted*	Ann.
1892	Browne, Mrs. E. T., *Anglefield, Berkhamsted*	Ann.
1897	Byrne, L. W., B.A., 7, *New Square, Lincoln's Inn, London, W.C.*	Ann.
*1903	Calman, Dr. W. T., *British Museum (Natural History), Cromwell Road, S.W.*	Ann.
†1884	Chamberlain, Rt. Hon. J., M.P., 40, *Prince's Gardens, S.W.*	Ann.
1911	Chilton, Prof. C., *Canterbury College, Christchurch, New Zealand*	Ann.
1884	Christy, Thomas Howard, 199, *Bramhall Lane, Stockport*	*C.*
1911	Clark, Dr. J., *Flowerbank, Kilmarnock, N.B.*	Ann.
1910	Clarke, G. B. R. Kitson, *Meanwoodside, Leeds*	Ann.
1887	Clarke, Rt. Hon. Sir E., K.C., 5, *Essex Court, Temple, E.C.*	£25
1885	Clerk, Major-General H., F.R.S., "*Mountfield*," 5, *Upper Maze Hill, St. Leonards-on-Sea, Sussex*	£21
1886	Coates and Co., *Southside Street, Plymouth*	*C.*
1910	Cole, Thomas Skelton, *Westbury, Endcliffe Crescent, Sheffield*	Ann.
1885	Collier Bros., *Old Town Street, Plymouth*	*C.*
1900	Cooper, W. F., B.A., *Ashlyns Hall, Berkhamsted*	Ann.
1909	Crawshay, L. R., M.A., *The Laboratory, Plymouth*	Ann.
1910	Darbishire, A. D., M.A., *The Zoological Department, The University, Edinburgh*	Ann.
1885	Darwin, Francis, F.R.S., 13, *Madingley Road, Cambridge*	*C.*
1885	Darwin, W. E., *Ridgemount Bassett, Southampton*	£20
1911	Davies, Humphreys, 6, *Southwick Place, London, W.*	Ann.
*1908	Dendy, Prof. A., F.R.S., *Firsdene, Oatlands Drive, Weybridge*	Ann.
1910	Devonport Education Authority	Ann.
1884	Dewick, Rev. E. S., M.A., F.G.S., 26, *Oxford Square, Hyde Park, W.*	*C.*
1885	Dixey, F. A., M.A. Oxon., *Wadham College, Oxford*	£26 5*s.* *and* Ann.
1906	De Morgan, W. C., *c/o National Provincial Bank, Plymouth*	Ann.
1910	Dobell, C. C., M.A., *Imperial College of Science and Technology, South Kensington, S.W.*	Ann.
1910	Drew, G. H., B.A., *The Laboratory, Plymouth*	Ann.
1890	Driesch, Hans, Ph.D., *Philosophenweg* 5, *Heidelberg, Germany*	*C.*
†1889	Ducie, The Rt. Hon. the Earl of, F.R.S., *Tortworth Court, Falfield, R.S.O.*	£50 15*s.*
1910	Duncan, F. Martin, *Spring Cottage, Oxted, Surrey*	Ann.
1884	Dunning, J. W., 4, *Talbot Square, London, W.*	£26 5*s.*
1884	Dyer, Sir W. T. Thiselton, M.A., K.C.M.G., F.R.S., *The Ferns, Witcombe, Gloucester*	*C.*
*1898	Eliot, Sir C. N. E., K.C.M.G., C.B., *Endcliffe Holt, Endcliffe Crescent, Sheffield*	Ann. £5

1906	Elliott, Sir Thomas H., K.C.B., *Board of Agriculture and Fisheries, 4, Whitehall Place, London, S.W.*	Ann.
1908	Elwes, Maj. Ernest V., *Glendower, St. Albans Road, Babbacombe*	Ann.
1893	Enys, John Davies, *Enys, Penryn, Cornwall*	Ann.
1885	Ewart, Prof. J. Cossar, M.D., *University, Edinburgh*	£25

1894	Ferrier, Sir David, M.A., M.D., F.R.S., 34, *Cavendish Square, W.*	Ann.
1884	Fison, Sir Frederick W., Bart., 64, *Pont Street, London, S.W.*	*C.*
1897	Foster, Richard, *Windsworth, Looe, R.S.O.*	Ann.
1885	Fowler, G. Herbert, B.A., Ph.D., *The Old House, Aspley Guise, Bedfordshire*	Ann.
1884	Fry, George, F.L.S., *Carlin Brae, Berwick-on-Tweed*	£21
*1907	Gamble, Prof. F. W., D.Sc., F.R.S., 38, *Frederick Road, Edgbaston, Birmingham*	Ann.
1906	Gardiner, Prof. J. Stanley, M.A., F.R.S., *Caius College, Cambridge*	Ann.
1907	Garstang, Prof. W., D.Sc., 2, *Ridge Mount, Cliff Road, Headingley, Leeds*	Ann.
1885	Gaskell, W. H., F.R.S., *The Uplands, Shelford, Cambridge*	*C.*
1901	Giles, Col. G. M., *Looseleigh, Crownhill, Plymouth*	*C.*
1910	Gooding, H. C., *Ipswich Street, Stowmarket*	Ann.
1910	Goodrich, E. S., F.R.S., *Merton College, Oxford*	Ann.
1885	Gordon, Rev. J. M., *St. John's Vicarage, Redhill, Surrey*	Ann.
1899	Guinness, Hon. Rupert, *Elveden, Thetford*	£35 15*s.*
†1884	Günther, Dr. Albert, F.R.S., 2, *Lichfield Road, Kew Gardens*	Ann.
1900	Gurney, Sir Eustace, *Sprowston Hall, Norwich*	Ann.

1884	Halliburton, Prof. W. D., M.D., F.R.S., *Church Cottage*, 17, *Marylebone Road, London, W.*	Ann.
1909	Hamilton, Dr. G. C., 21, *Finsbury Circus, London, E.C.*	Ann.
1884	Hannah, Robert, 82, *Addison Road, Kensington, W.*	*C.*
*1885	Harmer, S. F., D.Sc., F.R.S., *British Museum (Natural History), Cromwell Road, S.W.*	*C.*
1889	Harvey, T. H., *Cattedown, Plymouth*	Ann.
1888	Haselwood, J. E., 3, *Lennox Place, Brighton*	*C.*
1884	Haslam, Miss E. Rosa, *Ravenswood, Bolton*	£20
1884	Head, J. Merrick, F.R.G.S., J.P., *Pennsylvania Castle, Isle of Portland, Dorset*	Ann.
1884	Heape, Walter, *Greyfriars, Southwold, Suffolk*	*C.*
1910	Hefford, A.E., B.Sc., 43, *Parliament Street, London, S.W.*	Ann.
*1908	Hepworth, Commander M.W. Campbell, C.B., R.N.R., *Meteorological Office, South Kensington, London, S.W.*	Ann.
*1884	Herdman, Prof. W. A., F.R.S., *The Zoology Department, The University, Liverpool*	Ann.
1884	Herschel, Col. J., R.E., F.R.S., *Observatory House, Slough, Berks.*	*C.*
1889	Heywood, Mrs. E. S., *Light Oaks, Manchester*	*C.*
1910	Hicks, F., *Zoological Laboratory, King's College, London, W.C.*	Ann.
1884	Hickson, Prof. Sydney J., M.A., D.Sc., F.R.S., *Ellesmere House, Wilenslow Road, Withington, Manchester*	Ann.
1910	Hill, Dr. Alex., *Royston, Herts*	Ann.
*1907	Hill, Prof. J. P., *The Zoological Laboratory, University College, London, W.C.*	Ann.
1897	Hodgson, T. V., 54, *Kingsley Road, Plymouth*	Ann.

*1905 Holt, E. W. L., 46, *Lower Baggot Street, Dublin* .... Ann.
1909 Hoyle, W. E., M.A., D.Sc., *National Museum of Wales, City Hall, Cardiff* Ann.

1891 Indian Museum, *Calcutta* .... Ann.
1888 Inskip, Capt. G. H., R.N., 22, *Torrington Place, Plymouth* .... Ann.

1885 Jackson, W. Hatchett, M.A., D.Sc., F.L.S., *Pen Wartha, Weston-super-Mare* .... Ann.
1910 Jenkinson, J. W., D.Sc., 27, *Polstead Road, Oxford* .... Ann.
1911 Kirkpatrick, R., *British Museum (Natural History), Cromwell Road, S.W.* Ann.

1897 Lanchester, W. F., B.A., 19, *Fernshaw Road, Chelsea, London, S.W.* ... C.
1885 Langley, Prof. J. N., F.R.S., *Trinity College, Cambridge* .... C.
1895 Lister, J. J., M.A., F.R.S., *St. John's College, Cambridge* .... Ann.
1910 Liversedge, Prof. A., F.R.S., *Hornton Cottage, Hornton Street, Kensington* Ann.
1910 Lucas, Keith, M.A., *Trinity College, Cambridge* .... Ann.

1885 Macalister, Prof. A., F.R.S., *St. John's College, Cambridge* .... Ann.
1884 MacAndrew, James J., *Lukesland, Ivybridge, South Devon* .... Ann.
*1910 MacBride, Prof. E. W., M.A., D.Sc., F.R.S., *Royal College of Science, South Kensington, S.W.* .... Ann.
1900 Macfie, J. W. Scott, *Rowton Hall, Chester* .... C.
1902 Major, Surgeon H. G. T., 24, *Beech House Road, Croydon* .... C.
1889 Makovski, Stanislaus, *Saffrons Corner, Eastbourne* .... Ann.
1885 Marr, J. E., M.A., F.R.S., *St. John's College, Cambridge* .... C.
1902 Martin, C. H., *The Hill, Abergavenny* .... Ann.
1906 Masterman, A. T., D.Sc., *Board of Agriculture and Fisheries (Fisheries Division)*, 43, *Parliament Street, London, S.W.* .... Ann.
1910 Matthews, D. J., *The Laboratory, Plymouth* .... Ann.
1910 McClean, W. N., 63, *Evelyn Gardens, South Kensington, S.W.* .... Ann.
1884 McIntosh, Prof. W. C., F.R.S., *Nevay Park, Meigle, N.B.* .... C.
1884 Michael, Albert D., *The Warren, Studland, nr. Wareham, Dorset* ...... C.
1909 Midgley, J. H., *Grange-over-Sands, Lancs.* .... Ann.
1903 Mill, H. R., D.Sc., 62, *Camden Square, London, N.W.* .... Ann.
1899 Minchin, Prof. E. A., 4, *Tennyson Mansions, Cheyne Row, Chelsea, S.W.* Ann.
*1905 Mitchell, P. Chalmers, D.Sc., F.R.S., Secretary Zoological Society, *Regent's Park, London, N.W.* .... Ann.
1906 Morford, Rev. Augustin, *The Friary, Saltash, Cornwall* .... Ann.
1910 Müller, Prof. Hugo, F.R.S., 13, *Park Square East, Regent's Park, London, N.W.* .... Ann.
†1896 Murray, Sir John, K.C.B., F.R.S., *Challenger Lodge, Wardie, Edinburgh* Ann.

†1884 Norman, Rev. A. M., M.A., D.C.L., F.R.S., *The Red House, Berkhamsted, Herts* .... Ann.

1910 Orton, J. H., B.Sc., *The Laboratory, Plymouth* .... Ann.

1910 Pennell, Lieut. H., *Awliscombe, Honiton, Devon* .... Ann.
1906 Plymouth Corporation (Museum Committee) .... Ann.
1910 Plymouth Education Authority .... Ann.
1906 Port of Plymouth Incorporated Chamber of Commerce .... Ann.
1910 Porter, Horatio, 16, *Russell Square, London, W.C.* .... Ann.

1910	Preston, H. B., F.Z.S., 53, *West Cromwell Road, London, S.W.*	Ann.
1884	Pye-Smith, P. H., M.D., 48, *Brook Street, W.*	*C.*
1893	Quintin, St. W. H., *Scampstone Hall, Rillington, Yorks*	Ann.
1892	Rüffer, M. A., M.D., *Conseil Sanitaire, Maritime et Quarentenaire, Alexandria, Egypt*	Ann.
1911	Saunders, J. T., B.A., *Christ's College, Cambridge*	Ann.
1888	Scharff, Robert F., Ph.D., *Science and Art Museum, Dublin*	Ann.
1901	Schiller, F. W., *Butterhill, Stafford*	Ann.
*1909	Schuster, Edgar, D.Sc., 110, *Banbury Road, Oxford*	Ann.
1884	Sclater, P. L., F.R.S., *Odiham Priory, Winchfield, Hants*	Ann.
1884	Sclater, W. L., *Odiham Priory, Winchfield, Hants*	Ann.
1885	Scott, D. H., M.A., Ph.D., F.R.S., *East Oakley House, Oakley, Hants*	*C.*
1903	Scott, S. D., *Thirlestaine Villa, Cheltenham*	Ann.
1884	Sedgwick, Prof. A., M.A., F.R.S., *Royal College of Science, South Kensington, S.W.*	*C.*
1888	Serpell, E. W., *Loughtonhurst, West Cliff Gardens, Bournemouth*	£50
1900	Sexton, L. E., 3, *Queen Anne Terrace, Plymouth*	Ann.
1904	Shaw, Joseph, K.C., *Bryanston Square, London, W.*	£13
1908	Shearer, Dr. Cresswell, 30, *Thompson's Lane, Cambridge*	Ann.
1885	Sheldon, Miss Lilian, *High Park, Bideford*	Ann.
*1884	Shipley, Arthur E., M.A., F.R.S., *Christ's College, Cambridge*	*C. and* Ann., £5
1886	Shore, T. W., M.D., *Woodlawn, Kingswood Road, Upper Norwood, London, S.E.*	Ann.
1885	Sinclair, F. G., *Friday Hill, Chingford, Essex*	*C.*
1891	Sinclair, William F., 102, *Cheyne Walk, Chelsea, S.W.*	*C.*
1884	Skinners, the Worshipful Company of, *Skinners' Hall, E.C.*	£42
1889	Slade, Rear-Admiral E. J. W., R.N., M.V.O., H.M.S. *Hyacinth, East Indies Station*	*C.*
*1910	Smith, Geoffrey W., *New College, Oxford*	Ann.
1888	Spencer, Prof. W. Baldwin, M.A., F.R.S., *University of Victoria, Melbourne*	Ann.
1907	Sprague, Thomas Bond, M.A., LL.D., 29, *Buckingham Terrace, Edinburgh*	Ann.
1897	Straker, J., LL.M., F.Z.S., *Oxford and Cambridge Club, S.W.*	*C.*
*1899	Thompson, Prof. D'Arcy W., C.B., *University College, Dundee*	Ann.
1890	Thompson, Sir H. F., Bart., 9, *Kensington Park Gardens, London, W.*	Ann.
1884	Thornycroft, Sir John I., F.R.S., *Eyot Villa, Chiswick Mall*	Ann.
1906	Tims, H. W. Marett, M.D., 8, *Brookside, Cambridge*	Ann.
1903	Torquay Natural History Society, *Torquay*	Ann.
*1897	Travers, J. A., *Tortington House, Arundel*	Ann.
1910	Travers, R. C., *Tortington House, Arundel*	Ann.
1891	Vaughan, Henry, 325, *High Holborn, London*	*C.*
1884	Walker, Alfred, O., *Ulcombe Place, Maidstone*	Ann.
1884	Walker, P. F., 36, *Prince's Gardens, S.W.*	Ann.
1910	Wallace, W., D.Sc., 43, *Parliament Street, London, S.W.*	Ann.
†1884	Walsingham, The Rt. Hon. Lord, F.R.S., *Merton Hall, Thetford*	£20
1906	Waterhouse, N.E., 3, *Fredericks Place, Old Jewry, London, E.C.*	Ann.
1909	Waters, Arthur W., F.L.S., *Alderley, McKinley Road, Bournemouth*	Ann.

1909 Watson, A. T., *Southwold, Tapton Crescent Road, Sheffield*.................. Ann.
1906 Weldon, Mrs., *Merton Lea, Oxford* .... Ann
1910 Willes, W. A., *Elmwood, Cranborne Road, Bournemouth* .... Ann.
1900 Willey, A., D.Sc., F.R.S., *McGill University, Montreal, Canada* .... Ann.
1908 Williamson, Lieut. H. A., R.N., *H.M.S. Forth, Plymouth* .... Ann.
1884 Wilson, Scott, B., *Heather Bank, Weybridge Heath* .... *C.*
1900 Wolfenden, R.N., M.D., *The Grange, Sidcup, Kent* .... Ann.
1905 Woolf, M. Yeatman, *Wimpole House, Wimpole Street, London, W.*...... Ann.
1898 Worth, R. H., 42, *George Street, Plymouth* .... Ann.

IV.—Associate Members.

1889 Caux, J. W. de, *Great Yarmouth.*
1889 Dannevig, Capt. G. M., *Arendal, Norway.*
1904 Donnison, F., *Deep Sea Fishing Co., Boston.*
1904 Edwards, W. C., *Mercantile Marine Office, St. Andrew's Dock, Hull.*
1904 Freeth, A. J., *Fish Quay, North Shields.*
1904 Hurrell, H. E., 25, *Regent Street, Yarmouth.*
1904 Inskip, H. E., Capt., R.N., *Harbour Master's Office, Ramsgate.*
1904 Johnson, A., *Fishmongers' Company, Billingsgate Market, London, E.C.*
1889 Olsen, O. T., F.L.S., F.R.G.S., *Fish Dock Road, Great Grimsby.*
1904 Patterson, Arthur, *Ibis House, Great Yarmouth.*
1889 Ridge, B. J., *Newlyn, Penzance.*
1901 Sanders, W. J., *Rockvall, Brixham.*
1889 Sinel, Joseph, 8, *Springfield Cottages, Springfield Road, Jersey, C.I.*
1890 Spencer, R. L., *L. and N.W. Depôt, Guernsey.*
1890 Wells, W., *The Aquarium, Brighton.*

Some Cases of New Growths in Fish.

By

G. Harold Drew,

Beit Memorial Research Fellow.

With Plate IV.

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A FIBRO-SARCOMA OF RAIA MACRORHYNCHUS.

THIS specimen, obtained from one of the Plymouth trawlers, consisted of a large tumour on the dorsal surface, near the left angle of the fin (see Figs. 1 and 2). Only part of the fish was available for examination, so the presence of metastases and other details could not be determined.

The tumour was roughly circular, measuring about 4 inches in diameter, and was elevated above the skin about 1¼ inches. It consisted of a broad central pedicle, hard and fibrous and white in colour, surrounded by a broad cauliflower-like mass of a greyish colour, and of much softer consistency than the central mass. This peripheral part of the tumour was covered by a very thin layer of epithelium which lined the outside of the pedicle and was continuous with the epidermis; it extended into all the folds and hollows of the outer papilliform portion of the tumour, but was absent over the flat upper extremity of the pedicle.

An incision made along a diameter of the growth, and carried down into the tissues of the fish, revealed the fact that the tumour arose from the fibrous perichondrium of one of the fin rays. The central mass consisted of closely packed strands of white fibrous tissue of pearly whiteness, running at first in a direction perpendicular to the skin, and then branching out into the surrounding ring of softer tissue.

Sections of the pedicle showed that it consisted of strands of typical white fibrous tissue; these were closely packed, but a few small round cells, having a somewhat indefinite nucleus, and little or no cytoplasm, were present between the fibres, and occasionally the elongated nuclei of the fibrous tissue cells were observable. Sections of the softer peripheral part of the tumour (Fig. 3) showed irregular loosely packed strands of fibrous tissue containing a few elongated nuclei, and large numbers of the small round cells, described above, often occurring in small aggregations between the strands and fibrils of the fibrous tissue stroma. No definite blood-vessels were present, and blood spaces were rare. Superficially this portion of the growth was entirely covered by a single layer of squamous epithelial cells continuous with the epidermis, but there was nothing in this covering corresponding to the other layers of the skin, and no denticles or mucous glands were present.

It would thus appear that the tumour had been originally a simple fibroma arising from the perichondrium of one of the fin rays, and that later this had taken on a sarcomatous type, and had proliferated freely. Considering the very poor blood supply to the peripheral part of the tumour, the fact that this portion should have become of a distinctly sarcomatous nature, its evident free proliferation, and the absence of necrosis, is remarkable.

AN ENDOTHELIOMA OF AN EEL (CONGER VULGARIS).

This tumour was found on an eel caught at Plymouth. The fish was an immature female, about four feet long, and appeared in good condition.

The growth consisted of a nearly spherical mass in the region of the basi-hyal; it was about 1 inch in diameter and protruded about $1\frac{1}{4}$ inches from the level of the skin. The tumour was of a whitish colour, but in parts was somewhat haemorrhagic; the surface was rough and irregular, with, in places, minute pits lined with thickened epidermis. The skin was not continuous over the surface of the growth, but gradually thinned away at its margin until the junction of skin and tumour became indistinguishable and inseparable. The outer portion of the growth was moderately soft, but it felt as though there was a hard central part which was continuous with the basi-hyal; the arrangement suggested a considerable outgrowth of thickening of the basi-hyal in an anterior direction, and that this outgrowth had penetrated through the skin and become closely adherent to it at the margin. An incision made along a diameter of the tumour showed a central bone-like core, apparently formed by an outgrowth of the basi-hyal, and small areas of highly vascular tissue interspersed among patches of white fibrous tissue, in some of which deposition of lime salts was taking place. Other areas appeared semicartilaginous and some seemed myxomatous.

Microscopic sections presented very varying pictures according to the particular part of the tumour from which they were taken. The central part of the mass, after decalcification, could be recognised as consisting of fibrous tissue in which a considerable deposition of lime salts had taken place; this mass surrounded and merged into the bony tissue of the basi-hyal, and was penetrated in all directions by narrow blood spaces. These spaces were filled with blood corpuscles and rounded cells with large nuclei and distinct nuceoli; the amount of surrounding cytoplasm varied considerably in different cells, but was seldom great. From the fact that these blood spaces were more plentiful in the outer part of the central mass and did not penetrate to the centre, it would seem probable that the hard fibrous tissue had first been formed and had undergone partial calcification, and that then it had been invaded by the formation of ingrowing capillary blood spaces. Other sections from the softer parts of the tumour showed areas of loose and compact fibrous tissue, and other areas undergoing myxomatous degeneration: blood corpuscles and the rounded cells described above were present in varying numbers in almost every part of the growth. The surface of the marginal part of the tumour was irregularly covered with the cutaneous epithelium which had a tendency to form ingrowths of compact masses of epithelial cells, but did not show signs of becoming epitheliomatous. The more highly cellular portions of the growth presented the appearance shown in Fig. 6. Masses of rounded epithelioid cells were present, and irregular channels containing blood corpuscles could be distinguished between the cell masses. The boundaries of these channels showed a more or less regular arrangement of the epithelioid cells, which in places had a tendency to become elongated in the direction of the long axis of the blood channel; many of these cells were also present among the corpuscles in the blood spaces. In addition to these spaces with very ill-defined boundaries, other blood channels with more definite walls, usually circular in section, and more resembling capillaries, were present. These channels were bounded by a very delicate sheath, but no endothelium within the sheath could be distinguished. Comparatively few mitoses were observed in any of the sections, so it is probable that the growth was not extending rapidly at the time of examination.

The tumour can obviously be diagnosed as an endothelioma, arising from the endothelium of the blood vessels, and it appears identical in structure, growth, and arrangement of the cells to similar endotheliomata occurring in man.

No metastases were present.

A FIBRO-SARCOMA OF A PLAICE (PLEURONECTES PLATESSA).

This tumour was found on a plaice caught at Plymouth, and was brought up to the Laboratory a few hours after death. The fish was a female, 12 inches long, and was in good condition.

The growth consisted of a white ovoid mass situated over the operculum on the ocular surface of the fish. It measured about $\frac{3}{4}$ inch by $\frac{1}{2}$ inch along its longest and shortest axes respectively. It was soft to the touch and was covered with a very delicate epithelial layer containing a few pigment cells. Sections showed that the tumour was a fibro-sarcoma, similar to the fibromata and fibro-sarcomata that are relatively of such common occurrence on the opercula of plaice, but in this case the sarcomatous element prevailed to a much greater extent than usual. No metastases were present.

A TUMOUR OF A WHITING (GADUS MERLANGUS).

This tumour occurred in a male whiting, measuring 20 inches in length, caught at Plymouth. Its position and relative size are shown in Fig 4. It was soft in consistency, greyish in colour, but flecked with red from the presence of blood-vessels. The surface was bare and uncovered by the cutaneous epithelium. A median incision showed that the tumour arose from the fibrous tissue layer forming the dermis; there was no tendency to invade the subjacent muscles, and no metastases were present.

Sections (Fig. 5) showed that the growth consisted of a uniform reticulum of fine strands of some fibre-like substance, containing a number of small rounded cells with little or no cytoplasm, which were usually arranged along the fibres. These cells were seldom aggregated together into masses, and no mitoses were observed. A few more elongated nuclei resembling those of fibroblasts were seen, and irregular spaces filled with blood corpuscles were present.

At first sight the tumour somewhat resembled a fibrinous exudate of inflammatory origin, but a more careful examination and comparison of the small round cells with the normal leucocytes of the blood of the whiting showed that they had little in common, and the delicate reticulum of which the growth was chiefly composed in reality bears little resemblance to any exudate or tissue produced as an inflammatory reaction.

It seems probable that the tumour arose from a peculiar type of pathological multiplication of connective tissue cells, or fibroblasts, and so is perhaps related to the sarcomata, but until more extended observations can be made on other cases, this must remain as the merest surmise.

HAEMANGIOMATA OF A SPOTTED RAY (RAIA MACULATA) AND OF A GURNARD (TRIGLA LINEATA).

These tumours were accompanied by the presence of parasitic copepods; unfortunately in each case the body of the copepod had been broken off, leaving merely the haustoria imbedded in the growth, so that their species could not be determined.

In the case of the gurnard a small reddish soft tumour was present on the inner surface of the operculum; in the case of the ray, a similar tumour was present on the skin in the mid-ventral line of the body at the level of the fifth gill arch.

Sections showed a condition identical with the capillary Haemangiomata found in man. The tumours consisted of an irregular mass of dilated thin-walled capillaries filled with blood cells: the haustorial branches of the parasites could be easily recognised in the middle of each tumour.

In these cases it is impossible to say whether the tumours developed first, and then were attacked by the parasitic copepods, or whether they represent a peculiar type of reaction on the part of the host to the presence of the parasite. The former alternative would seem the more probable, since in by far the majority of cases of infection by parasitic copepods, little or no sign of an inflammatory reaction on the part of the host is present.

A PIGMENTED TUMOUR OF A MACKEREL (SCOMBER SCOMBER) OF INFLAMMATORY ORIGIN.

This fish, a male, 11 inches in length, caught at Plymouth, showed a large diffuse swelling on its side, situated about 3 inches from the tail. The surface of the skin was not broken, but was very darkly pigmented.

On cutting through the skin and deep into the subjacent muscular tissue, the cut surface appeared soft, haemorrhagic and degenerated, and was of a brownish colour; in places small black specks, due to the aggregation of pigment granules into masses, were visible to the naked eye. The swelling was not circumscribed, but passed imperceptibly into the surrounding normal muscular tissue: the vertebral column was not affected.

Sections of the diseased area presented an appearance superficially resembling a melanotic sarcoma, so much so that without some experience of the histology of inflammation and muscular degeneration in fish, it might very easily be diagnosed as such. The sections showed that there was a great increase in the number of the muscle nuclei, and loss of definite striation of the fibres, followed by atrophy: some increase in the amount of fibrous tissue surrounding the muscle bundles had taken place, and in many cases this thickened muscle sheath was filled only with muscle nuclei and leucocytes, all trace of the muscle itself having disappeared. Fibroblasts in all stages of division were present as well as many leucocytes.

The blood capillaries in the neighbourhood were dilated, and in regions where the inflammatory process was most severe, irregular blood spaces without definite walls were found. The whole of the diseased area was crowded with minute pigment granules, often aggregated into small masses; many of the leucocytes contained large numbers of these pigment granules, but otherwise the granules were always extra-cellular. The skin showed little sign of disease, but contained a few pigment granules in the dermis, deposited in thin layers parallel to the surface; the most intense area of pigmentation was between the dermis and the muscles, where an almost continuous sheet of pigment had been formed.

I have experimentally produced a condition closely resembling this melanotic myositis by long-continued repetition of the application of a strong solution of Iodine to a circumscribed area of the skin of Fundulus heteroclitus. In cases where the irritation due to the Iodine was sufficiently intense to cause inflammation of the subdermal muscular tissue, a condition characterised by atrophy of the muscles, great multiplication of the muscle nuclei, and development of pigment granules, accompanied by the usual phenomena of inflammation, was produced. In this case also the presence of numbers of cells arising by multiplication of the muscle nuclei, together with the pigment granules and leucocytes, gave at first sight a picture suggestive of a sarcomatous growth of a melanotic type.

The particular swelling here described as occurring in a mackerel may thus be considered as a melanotic myositis of unknown cause, and it is perhaps worthy of note that the formation of granules of a pigment apparently resembling melanin can be artificially produced in the tissues of fish by causing mild but continued inflammation.

DESCRIPTION OF PLATE IV.

Illustrating Mr. G. H. Drew's paper on "Some Cases of New Growths in Fish."

Fig. 1 × $\frac{5}{8}$. Photograph of Fibro-sarcoma of Raia macrorhynchus, cut open to show internal surface and origin from perichondrium of one of the fin rays.

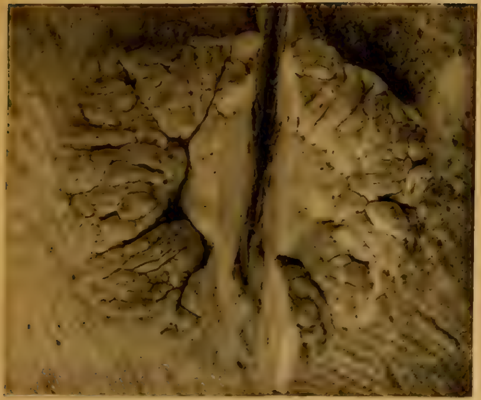

FIG 1.

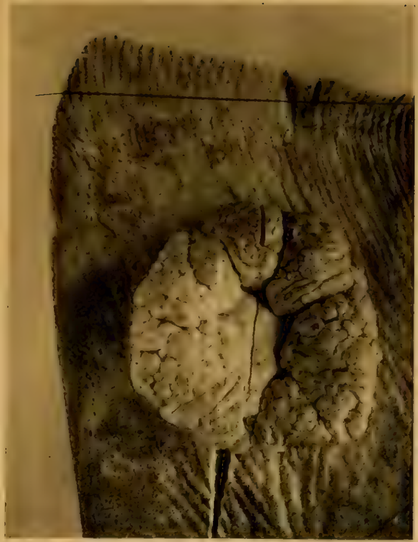

FIG 2.

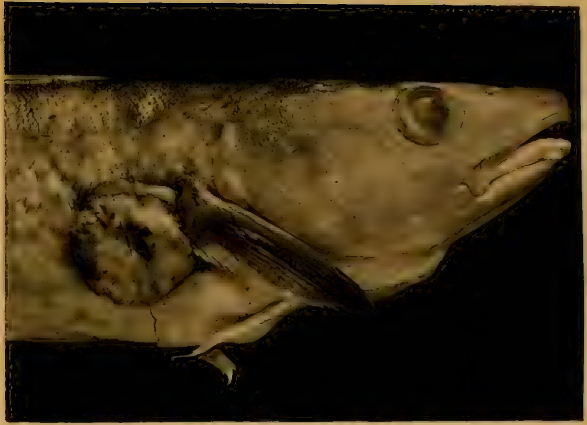

FIG 4.

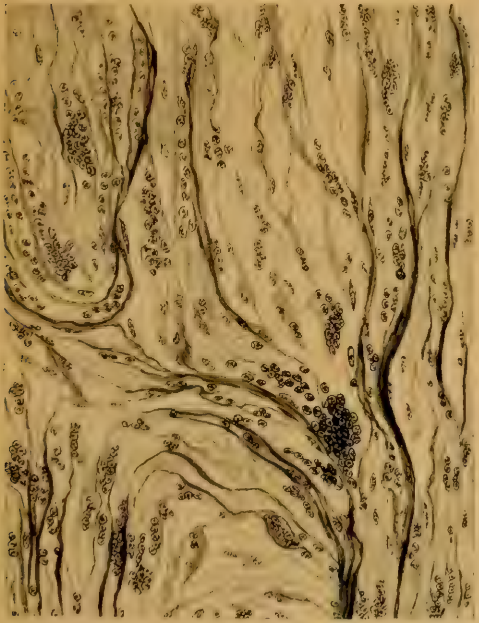

FIG 3.

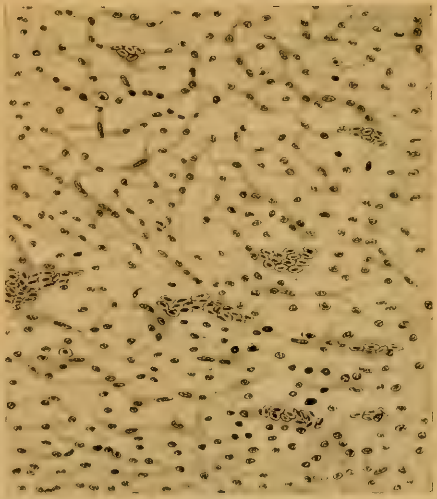

FIG 5.

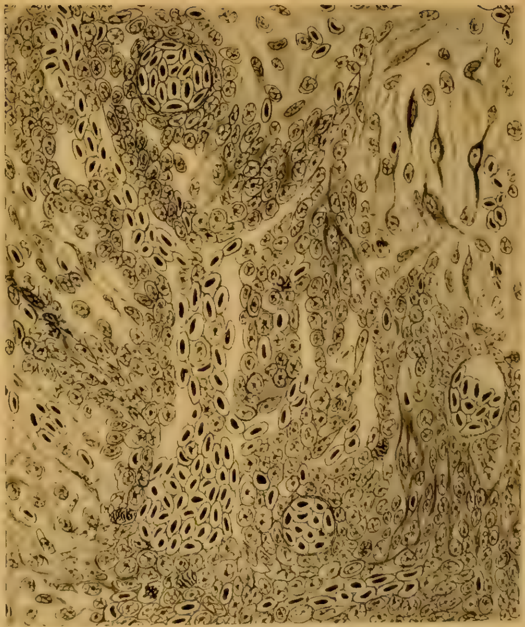

FIG 6.

Fig. 2 × $\frac{7}{18}$. As Fig. 1, but showing position of tumour on the fin.

Fig. 3 × 150. Section of tumour shown in Figs. 1 and 2. Irregular strands of fibrous tissue are present, with numbers of small round sarcomatous cells.

Fig. 4 × $\frac{1}{2}$. Photograph of Whiting, showing position of the tumour.

Fig. 5 × 150. Section of tumour shown in Fig. 4. A fine reticulum of a fibrous nature forms the groundwork of the growth, and small round cells are situated on the strands forming this reticulum. Spaces containing corpuscles are present.

Fig. 6 × 400. Section of endothelioma of Eel. Masses of endothelial cells divided by irregular spaces containing blood corpuscles are present, together with some blood spaces with more definite walls.

(N.B.—For the sake of clearness the red blood corpuscles are represented with dense black nuclei, showing none of their nuclear structure.)

Notes on the Respiratory Mechanism of Corystes Cassivelaunus.

By

Kathleen E. Zimmermann, B.Sc.,

University College of Wales, Aberystwyth.

With Plate V.

I. INTRODUCTION.

In his paper in the Journal of the Marine Biological Association for August, 1896, Garstang treated of some structural peculiarities of *Corystes cassivelaunus* in relation to their biological significance. A brief summary of his observations on the respiratory mechanism may be given as follows: In *Corystes cassivelaunus* the second antennae are greatly elongated and are fringed by a ventral and a dorsal row of hairs. The opposing rows of hairs interlock, with the resulting formation of a median "antennal tube." The double row of hairs is continued back along the three basal joints of the antennae, which joints are bent at right angles to one another; these hairs, projecting towards the median line, together with a median tuft of hairs springing from the rostrum, form the hairy roof of the proximal part of the antennal tube. The antennal tube opens posteriorly into a median "prostomial chamber," which in turn leads by a wide aperture to the branchial cavity of each side. The prostomial chamber is roofed by the rostrum, the antennal and epistomial sternites, and the prelabial plate. Its floor is imperfect, and is formed by the anterior part of the third maxillipeds behind and in front by a quadrangular sieve of hairs springing from the two basal joints of the second antennal, the anterior pterygostomial processes, and a special anterior process of the fourth joint of the external maxillipeds.

The habit of Corystes is to burrow beneath the sand, where it remains concealed, with only the tip of the antennal tube projecting above the sand surface. A current of water (the respiratory current) is sucked down through the antennal tube, and passes backwards into the prostomial chamber, where it divides into right and left streams, which pass into the right and left branchial chambers. The stream eventually emerges from the branchial chamber along the whole extent of the edge of the branchiostegite.

II. SOME STRUCTURAL PECULIARITIES WHICH APPEAR TO HAVE PASSED UNNOTICED BY GARSTANG.

On that part of the ventral body wall which forms the posterior part of the dorsal wall of the prostomial chamber is a fairly prominent calcified V-shaped ridge, the point of the V being directed backwards. This ridge is formed by the projecting anterior edge of the epistomial sternite, and is fringed with a row of fairly long hairs, which project quite halfway across the entrance to each branchial chamber.

Some of the mouth appendages of *Corystes cassivelaunus*—first maxilla and first maxillipede—show a rather curious modification. Comparing these appendages with those corresponding to them in such a type as Cancer (*vide* Pearson's "Cancer," L.M.B.C. Memoirs, No. xvi), the enlargement of the endopodite is very noticeable. Corystes has the endopodite lobe of each of these appendages (Figs. 4 and 5) specially produced and fringed with hairs of a fairly complex type (Fig. 7).

The mandible of each side is placed with its "apophysis" pointing obliquely backwards, and forming a very prominent ridge projecting towards the ventral side of the animal. Across this ridge lie the specially enlarged endopodite lobes of appendages iv and vi, and over it they are turned up in a dorsal direction, so that their hairy fringes project across the entrance to the branchial chamber proper, meeting the fringe of hairs arising from the V-shaped ridge of the epistomial sternite (cf. Figs. 1, 2 and 3).

Garstang himself notes that the prostomial chamber is but imperfectly floored; it is noticeable that to its central part there is no floor whatever, even a hairy one; and even around its sides the hairs which spring from different parts and converge to the centre neither interlock to any great degree, nor have sufficient individual complexity of structure to constitute anything like a barrier to restrain the in-current of water.

The simple structure of the hairs on the antennae should be noted (Fig. 6): there is complete absence of any kind of arrangement for filtering the water as it passes from the exterior into the antennal tube, and thence into the prostomial chamber. The habit of *Corystes cassivelaunus* is to lie buried in sand; the water directly above the surface must necessarily contain some particles of sand or mud, and it is from this by no means clear water that the supply for the respiratory stream is drawn. The complete absence of any arrangement for filtering the water of the incoming current has already been noted, but the sieve-like partition formed by the hairs projecting from the specialised endopodites of appendages IV and VI (Fig. 7), together with those of the epistomial ridge, appears to constitute a very efficient filter by which particles are rejected at the entrance to the branchial chamber itself. [N.B.—In specimens examined, the hairs of this strainer are muddy.]

The in-current, on reaching the posterior part of the prostomial chamber, must be slightly affected by the presence of the dorsal V-ridge, which, however, seems to be not of sufficient importance to change the course of the whole body of the current. The main mass of the current doubtless sweeps on, is split into right and left streams along the arms of the inverted V formed by the apophyses of the mandibles, and enters the branchial chambers; meanwhile the small secondary current produced by the influence of the epistomial ridge flows out ventrally through the gap in the hairy ventral wall of the prostomial chamber, sweeping away in its course such particles of mud, etc., as have been prevented by the hairy sieve from entering the branchial chambers with the main current.

SUMMARY.

Corystes buries itself in sand for protection, with the tip of the antennal tube, through which enters the respiratory current, projecting. The water which enters the antennal tube cannot be quite clear: there is a hairy filter, which rejects particles of mud, etc., at the entrance to each branchial chamber. The main body of the in-current is split into right and left currents, owing to the position of the apophyses of the mandibles, and these two currents enter respectively the right and left branchial chambers. The epistomial ridge on the roof of the prostomial chamber turns aside some portion of the in-current, which portion passes out ventrally through a gap in the floor of the chamber, carrying out with it foreign particles brought in by the in-current and rejected by the sieves guarding the entrances to the branchial chambers.

EXPLANATION OF PLATE V.

Fig. 1. Front end of body of *Corystes cassivelaunus*, ventral view.
  a. incompleteness in hairy floor of prostomial chamber.

Fig. 2. View of prostomial chamber from ventral side after removal of most of the mouth appendages.
  a. epistomial ridge, fringed with hairs.
  b. labrum.
  c. entrance to branchial chamber of left side.
  d. mandible.

Fig. 3. Diagram longitudinal section a little to one side of the median line.
  a. position of antennal tube.
  b. prostomial chamber.
  c. hairy strainer.
  d. branchial chamber.
  e. hairs flooring prostomial chamber.
  f. position of maxillae.
  g. gap in the hairy floor.

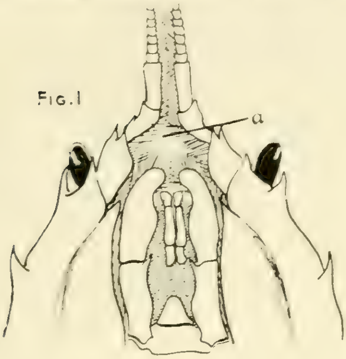

FIG. 1

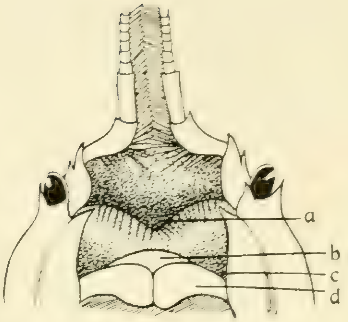

FIG. 2

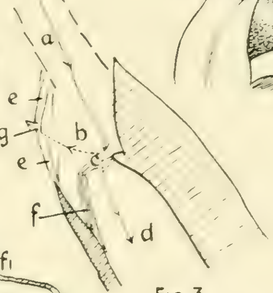

FIG. 3.

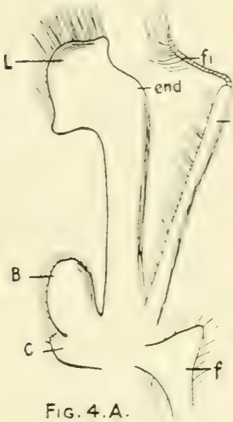
L
f1
end
ex
B
C
f

FIG. 4.A.

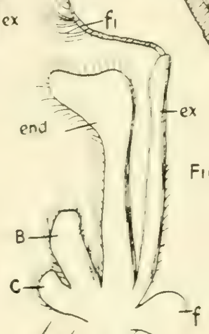
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FIG. 4.B.

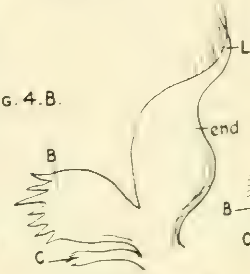

FIG. 5.A.

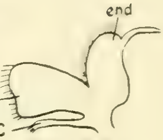

FIG. 5.B.

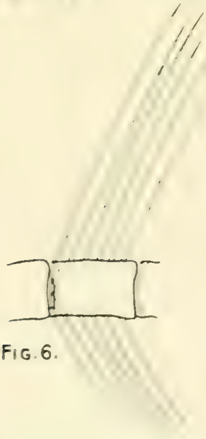

FIG. 6.

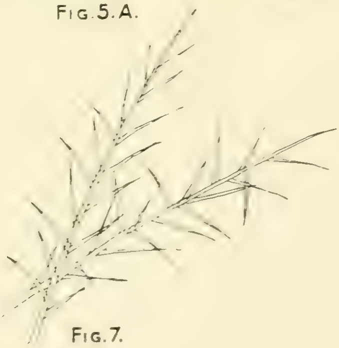

FIG. 7.

Fig. 4A. First maxillipede of Corystes.
B. basipodite.
C. coxopodite.
ex. exopodite.
fl. flagellum.

Fig. 4B. First maxillipede of Cancer.
f. flabellum.
end. endopodite.
l. special endopodite lobe, fringed with straining hairs.

Fig. 5A. First maxilla of Corystes.
Lettering as for 4.

Fig. 5B. First maxilla of Cancer.

Fig. 6. Part of antenna of Corystes, to show the two rows of simple hairs.

Fig. 7. Straining hairs, such as fringe the endopodites of 4 and 6 in Corystes.

On the Fauna of the Outer Western Area of the English Channel.

By

L. R. Crawshay, M.A.

With Plate VI.

In a previous number of this Journal* a Report was published by Mr. R. H. Worth on the geological collections made in the English Channel by the Association's steamer *Oithona* in 1906, combined with other previously unpublished geological records relating to the same area. The general features of the area concerned, with details of the dredgings on this occasion, were described by me (4) in an accompanying paper. It was hoped that the Report on the Fauna then collected, for which indeed the cruises were specially arranged, would be published long before now; but owing to unavoidable causes the complete working out of the material has been unfortunately delayed for a long interval.

The area of investigation as illustrated by the accompanying chart extends roughly from ten to fifty miles outside the Eddystone Lighthouse, in a S.W. Mag. direction, and ranges from 40 to 53 fathoms in depth, reaching about the mid-Channel line near the latter sounding. A few points already dealt with in the paper referred to may be repeated here. The nature of the ground over the whole area, with the exception of the first few miles, may be generally described as shell, sand, and gravel, largely intermixed with stones, which often reach very considerable dimensions, and show a gradual increase in average size as the distance increases outwards, the highest average being obtained near the outermost point that was reached. The inner limit of exposure of these stones was found at fifteen miles to the south-westward of the Eddystone. At positions falling inside this point the bottom deposit consists of a clean shell sand, much finer than is found at any other point in the area concerned.

As regards the gear employed, the otter trawl was used at Positions 3 and 4, within the fine sandy area last mentioned, and at Positions 7, 8, 49, 64, 66, 68 and 78, outside it; but the frequent occurrence of large stones involved too great a risk to use the otter trawl often at the outer positions, and with the exception of those taken with the Agassiz trawl at Positions 45, 46, 52, 59 and 60, all the remaining

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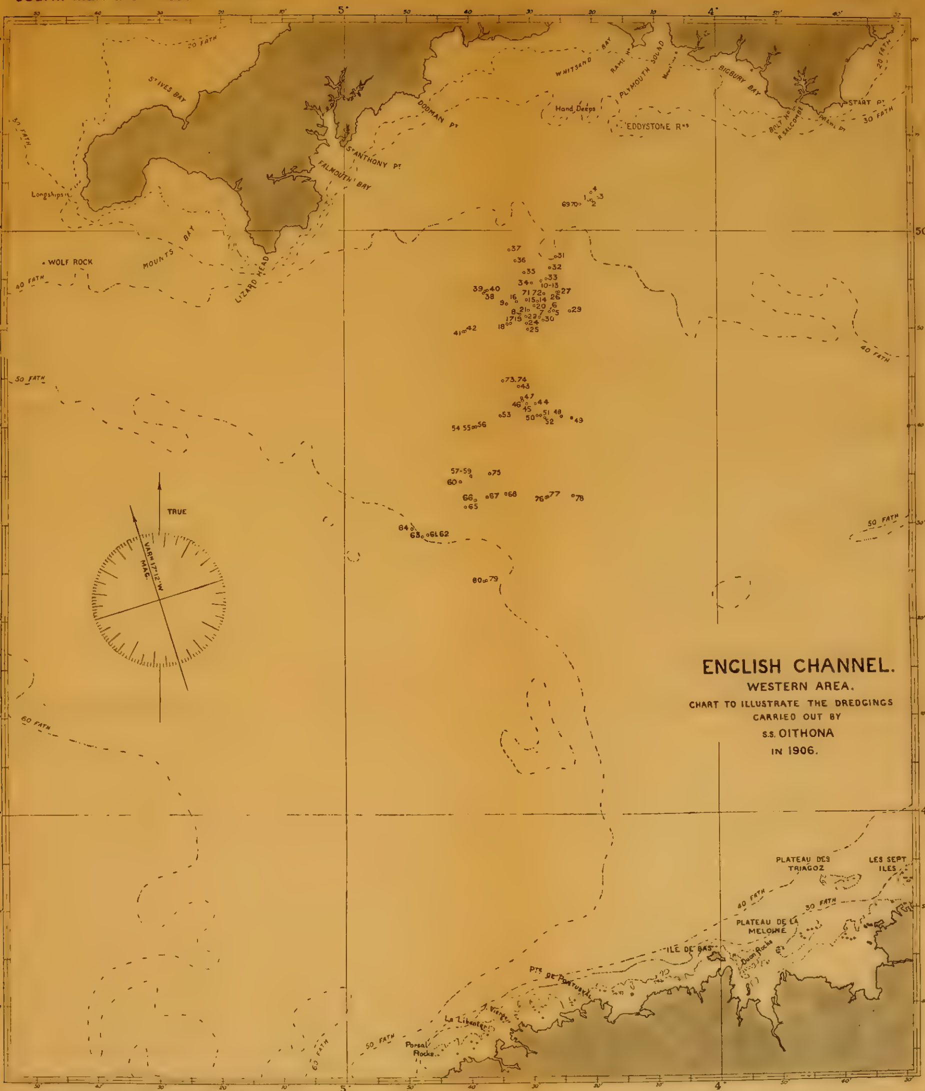
* *Journ. Mar. Biol. Assoc.*, N.S., Vol. VIII., p. 118.


20 FATH
ST IVES BAY
Longships
MOUNTS BAY
LIZARD HEAD
WOLF ROCK
40 FATH
DODMAN PT
ST ANTHONY PT
FALMOUTH BAY
WHITSAND BAY
RAME HD
PLYMOUTH SOUND
Hand Deeps
EDDYSTONE Rks
BIGBURY BAY
BOLT HD
R. SALCOMBE
START PT
PRAWL PT
30 FATH
50 FATH
60 FATH
TRUE
VARN 17°12' W
MAG.
PLATEAU DES TRIAGOZ
LES SEPT ILES
PLATEAU DE LA MELOINE
ILE DE BAS
Pte DE PONTUSVAL
La Libenter
Vierge
Porsal Rocks
Duon Rocks
5°
4°
50°
49°

ENGLISH CHANNEL.

WESTERN AREA.

CHART TO ILLUSTRATE THE DREDGINGS CARRIED OUT BY S.S. OITHONA IN 1906.

Crawshay. Fauna of Outer Western Area of the Channel.

hauls were made with the dredges. Of these latter, fifteen were bottom samples, most of them not exceeding one minute in working duration; fifteen were made with a 3 ft. rectangular dredge, averaging twelve minutes in duration; eighteen were made with a 3 ft. 6 in. rectangular dredge, averaging eight minutes in duration; and seventeen with an equiangular dredge, measuring 2 ft. on the side, averaging seven minutes in duration. The short length of these hauls must therefore be borne in mind in considering the intensity of occurrence of any of the species recorded. In the following list of hauls all positions are referred to their true bearing from the Eddystone Lighthouse. Samples 16 to 30 inclusive were taken more especially as rock samples, and in consequence only a rough record of species, made on board at the time, was preserved. They have not therefore the value of others in which the unidentified material was brought home for examination. They concern, moreover, a limited area, from eighteen to twenty-three miles outside the Eddystone, and in point of species recorded from them are merely additional to other hauls made within the same area.

LIST OF HAULS.

No.	True Bearing from Eddystone.	Distance. Miles.	Depth. Fathoms.	Gear Used.	Length of haul. Minutes.	Remarks.
1	S. 21° W.	8·3	40	3′ 0″ Dredge	15	
2	S. 19° W.	8·1	40	1′ 6″ Dredge with canvas bag	3	Bottom sample
3	S. 15° W.	7·8	40	Otter Trawl	30	
4	S. 21° W.	7·6		„ „	30	
5	S. 19° W.	20·2	42	3′ 0″ Dredge	15	
6	S. 20° W.	20·4	42	„ „	10	
7	S. 23° W.	21·2	42	Otter Trawl	30	
8	S. 27° W.	21·8		„ „	30	
9	S. 31° W.	21·7		3′ 0″ Dredge	20	
10	S. 26° W.	17·8	42½	„ „	5	
11	„	„	42½	„ „	10	
12	„	„	42½	„ „	10	
13	„	„	42½	„ „	17	
14	S. 24° W.	20·0		„ „	15	
15	S. 27° W.	20·3		„ „	10	
16	S. 29° W.	20·9	44	„ „	10	
17	S. 28° W.	23·3	45	„ „	11	
18	S. 29° W.	23·4	45	„ „	10	
19	S. 28° W.	23·3	45	„ „	10	
20	S. 25° W.	20·5	44	„ „	10	
21	„	21·2	44	Triangular Dredge	9	
22	„	21·9	44	„ „	4	

No.	True Bearing from Eddystone.	Distance. Miles.	Depth. Fathoms.	Gear Used.	Length of haul. Minutes.	Remarks.
23	S. 25° W.	21·9	44	Triangular Dredge	–	Bottom sample from previous haul
24	S. 24° W.	22·5		,, ,,	5	
25	,,	23·0	46	,, ,,	8	
26	S. 20° W.	18·4	44	,, ,,	8	
27	S. 19° W.	18·3	44	,, ,,	8	
28 29	S. 14° W.	19·8	44	,, ,,	7	
30	S. 21° W.	21·5	43½	,, ,,	10	
31	S. 25° W.	15·0	40	3′ 6″ Dredge	10	
32	,,	16·3		,, ,,	7	
33	,,	17·5		,, ,,	7	
34	S. 28° W.	18·5		,, ,,	8	
35	S. 32° W.	18·0		,, ,,	8	
36	S. 37° W.	17·5	43	,, ,,	8	
37	S. 41° W.	17·1		,, ,,	9	
38	S. 38½° W.	22·2	44	,, ,,	7	
39	S. 38° W.	21·9	44	,, ,,	4	
40	,,	21·7	44	Triangular Dredge	5	
41	S. 36½° W.	26·6	44	,, ,,	7	
42	S. 36° W.	26·4	44	,, ,,	6	
43	S. 21° W.	28·8	45	,, ,,	10	
44	S. 17° W.	29·8	46½	,, ,,	10	
45	S. 18° W.	30·1	47½	Agassiz Trawl	15	
46	S. 19° W.	29·9		,, ,,	15	
47	S. 19° W.	29·7		1′6″ Dredge with canvas bag	½	Bottom sample
48	S. 11° W.	30·5		,, ,,	½	Bottom sample
49	S. 9° W.	30·4		Otter Trawl	30	
50	S. 16° W.	30·9	43	1′ 6″ Dredge with canvas bag	2	Bottom sample
51	S. 15° W.	30·8	43	Triangular Dredge 3′ 6″ Dredge	5 10	The two consecutive samples were labelled "51" in error
52	S. 14° W.	31·0	43	Agassiz Trawl	25	
53	S. 22° W.	32·2	46	3′ 6″ Dredge	10	
54	S. 26° W.	34·5	49	1′ 6″ Dredge with canvas bag	1	Bottom sample
55	S. 25½° W.	34·4	49	,, ,,	1	
56	S. 25° W.	34·3	49	Triangular Dredge	4	
57	S. 22° W.	39·0	49	1′ 6″ Dredge with canvas bag	2	Bottom sample
58	,,	,,	49	3′ 6″ Dredge	10	
59	,,	,,	49	Agassiz Trawl	25	
60	S. 24° W.	40·0		,, ,,	30	

No.	True Bearing from Eddystone.	Distance. Miles.	Depth. Fathoms.	Gear Used.	Length of haul. Minutes.	Remarks.
61	S. 25° W.	46·4	50	1′ 6″ Dredge with canvas bag	1	Bottom sample
62	"	"	50	3′ 6″ Dredge	7	
63	S. 25½° W.	46·8	50	Triangular Dredge	7	
64	S. 27° W.	46·6	53	Otter Trawl	30	
65	S. 22° W.	42·2	52	1′ 6″ Dredge with canvas bag	1	Bottom sample
66	S. 21° W.	41·1		Otter Trawl	30	
67	S. 19° W.	40·5		Triangular Dredge	10	
68	S. 17° W.	39·6		Otter Trawl	55	
69	S. 25° W.	9·0	40	Conical Dredge	$\frac{1}{6}$	Bottom sample
70	"	"	40	3′ 6″ Dredge	11	
71	S. 23° W.	19.0	43	Conical Dredge	$\frac{1}{4}$	Bottom sample
72	"	"	43	3′ 6″ Dredge	7	
73	S. 24° W.	28.8	45	Conical Dredge	$\frac{1}{6}$	Bottom sample
74	"	"	45	3′ 6″ Dredge	4	
75	S. 20° W.	38·1	49	Conical Dredge	$\frac{1}{3}$	Bottom sample
76	S. 9° W.	38·9	49	" "	$\frac{1}{2}$	Bottom sample
77	S. 11° W.	38·8	49	3′ 6″ Dredge	7	
78	S. 7° W.	38·3		Otter Trawl	65	
79	S. 16° W.	48·7	51	Conical Dredge	$\frac{1}{4}$	Bottom sample
80	S. 16½° W.	48·9	51	3′ 6″ Dredge	7	

VII. Records of species made under this Roman numeral refer to a doubtful position in Cruise VII. In the course of this cruise, one of the labels of part of the material that had been collected was lost by a mishap, and it was not possible afterwards to locate the position. The cruise extended over an area of twelve miles in width, covered by the hauls 54 to 68, and the material can only be considered as belonging to one of these positions, ranging in depth from 49 to 53 fathoms.

The Director has given me much assistance with the Polychaeta and in many other ways. The few Gephyrea recorded were identified by Mr. G. Southern. The more difficult of the Polyzoa were worked out by Miss Alice Heath, and against records for which she is responsible the letter (H) is placed, as opposed to my own records followed by the letter (C). I have also to record my thanks to Dr. Hartmeyer for the naming of the Tunicata, with his notes on the species, subject to his most recent revision of that group; to Mr. A. E. Hefford for the identification of some of the Fishes; and to others who have kindly assisted me on special points arising. For the working out of the material, where not otherwise stated, I am myself responsible.

GENERAL REMARKS.

The most marked feature of the fauna of this outer area of the Channel is its close conformity in the main with that of the Plymouth neighbourhood. Regarding the latter as the area enclosed by a line passing from Start Point to the Eddystone Lighthouse and thence to Looe Island, the fauna of the outer area may be compared with that of the Plymouth neighbourhood under three heads, concerning (1) species common to both areas, (2) species occurring in the Plymouth area which are absent from the outer area, (3) species occurring in the outer area which are absent from the Plymouth area.

(1) By far the greater bulk of the material comes within this category. With the exception of those that can scarcely be considered among the commoner species, and which are therefore less often met with generally, and excluding strictly littoral species, the majority of the species were found extending with more or less frequency over the whole area. Reference here then will only be made to those more familiar species the limited records of which seem to point to a limit of distribution, or to species which call for special remark in other ways. Distances where mentioned are from the Eddystone Lighthouse, and roughly to the south-westward in direction.

PORIFERA. *Clathrina coriacea* was only once recorded. The species, usually of littoral habitat, gives place at about 18 miles to forms which I have referred to *Clathrina primordialis.* One of the latter approximates closely in spiculation to *C. coriacea*, and great as is the difference of spiculation between the two extremes, I am bound to admit a certain doubt as to whether a gradual transition may not prove to exist between them associated with a difference of habitat, in one and the same species.

Leucosolenia complicata, though occurring nearly everywhere, was remarkable for its slender, straggling habit of growth, possibly due to a lack of proper food-supply.

Sycon ciliatum was only obtained at two closely approximate positions about 22 miles distant. Outside this, the only closely allied species was the southern species, *Grantia capillosa*, which was obtained as close in as the first position, 8 miles distant. The latter species certainly also occurs near or even inside the Eddystone, though the few Plymouth specimens in the Laboratory Museum are without data of locality.

Leucandra fistulosa, generally distributed in the Sound, only once occurred at the first position, 8 miles distant.

Polymastia mammillaris, common at certain points on rocky ground in the Sound, was obtained only at 31 and 39 miles, in contrast to *P. robusta*, which occurred fairly commonly over the whole area.

Ficulina ficus, though of common occurrence as far as 40 miles out, was always of remarkably small size—much more so than it often occurs on the Eddystone Grounds. This reduction of growth, as contrasted with the comparatively enormous size it often attains within the breakwater, is no doubt attributable to the diminution of waste organic matter on the distant grounds.

Suberites carnosus, comparatively common on the Eddystone, Grounds was only twice found, at 17 and 22 miles respectively. These also were extremely small specimens.

HYDROMEDUSAE. Except at the first few positions, on the fine sand about 8 miles distant, and again at the outermost point reached, where in 51 fathoms two southern species showed a healthy luxuriant growth, the examples recorded were on the whole remarkably small, and the occurrence of well-grown colonies was quite exceptional. In the same connection the dwarfed form of *Plumularia setacea* at two outer positions in about 50 fathoms is remarkable.

Merona cornucopiae was taken as far as 31 miles distant, which was 10 miles beyond the outermost record of its common associate *Dentalium entalis.*

Hydractinia echinata was only taken at 31 miles.

Tubularia was only recorded at the first position, 8 miles distant.

Halecium halecinum was not recorded outside about the 34-mile point.

A fragment only of *Thuiaria articulata* was taken at 18 miles.

Antennularia ramosa, though occurring as far out as 40 miles, was not found common anywhere. The allied species, *A. antennina* was common over the whole area.

Plumularia catharina was the commonest of its genus obtained, *P. pinnata* alone approximating to it appreciably in point of frequency. The creeping variety, which occurred over the whole area, was perhaps the most frequent and certainly the most flourishing in point of growth. It is difficult to assign a cause for this mode of growth. A colony of *Bougainvillia*, reared by Mr. E. T. Browne at the Plymouth Laboratory some years ago (cf. *Journ. Mar. Biol. Assoc.*, N.S., Vol. VIII, p. 37) assumed a persistent stoloniferous habit of growth from the first. It was fed with mixed plankton regularly and grew rapidly, but in the several months of its existence, except in very rare cases, it made no attempt to assume the ordinary branching habit, even though it ultimately succumbed to an overgrowth of small algae. This single instance affords no evidence that food-supply alone influences the manner of growth where the latter is variable. Yet the seeming scantiness of the Hydroid fauna over most of the outer area, coupled with the frequent records of small colonies, and distinctly dwarfed colonies in the case of *P. setacea* point to conditions that are unfavourable to healthy growth in the group.

ECHINODERMATA. *Palmipes placenta* was not found outside the 17-mile point, and at the latter only as small specimens.

Echinus acutus was not recorded inside a distance of 15 miles, which is about the inner limit of the stony ground. *E. esculentus*, on the other hand, occurred over the whole area, and in considerably greater numbers.

POLYCHAETA. The outer limit of occurrence of *Aphrodita aculeata* was at 20 miles; that of the nearly allied *Hermione hystrix* extended to 46 miles. The latter species seems generally to favour grounds of a coarse character.

Halosydna gelatinosa occurred only at 39 miles.

Onuphis conchilega was not found beyond the 26-mile point.

CRUSTACEA. *Portunus depurator*, often an abundant species in the Sound, and found abundantly by Dr. Allen (1) 3 miles east of the Eddystone, was only once obtained at 17 miles.

Atelecyclus septemdentatus has been recorded from as much as 100 fath. and even 400 fath. (cf. Allen, 1), but in the area here considered it was not found beyond 30 miles. This species is scarcely likely to have been much missed in the work owing to the constant use of the dredges with a special view to deep working. Allen considers that a certain amount of muddy deposit contributes to the most favourable conditions for the species, and it is possible that the almost entire absence of any such deposit on the outer grounds may explain its infrequency and even disappearance at the more distant positions visited.

MOLLUSCA. *Craspedochilus onyx* was not recorded beyond 20 miles.

Capulus hungaricus, taken on five grounds by Dr. Allen between Start Point and the Eddystone, at 30 fathoms, was not found alive in the area here under consideration, though dead shells occurred as far out as 27 miles.

Of *Pecten maximus* there is a noticeable scarcity at all points as contrasted with *P. opercularis*, which was at times abundant. About five living specimens were obtained at three positions, all situated about 20 miles out. At other positions from one to three only occurred, and the total number obtained probably did not exceed forty. On the grounds near the Eddystone it was found by Dr. Allen with much greater frequency, two or three specimens being generally taken in each haul with the dredge.

Dentalium entalis was not found outside the 18-mile point.

Nucula nucleus, which occurs commonly down to 30 fathoms on the Eddystone Grounds, was only obtained at the first position, 8 miles distant, where the large deposit of fine clean sand occurs.

Pectunculus glycimeris, occurring as far as 39 miles out, was remarkable for the small size of specimens obtained.

Cardium echinatum was of rare occurrence, being only once obtained alive at 9 miles distant, while only one dead valve was recorded at a point slightly closer in.

Cardium norvegicum, common on gravel on the Eddystone Grounds, was only recorded at four points, and as far as 31 miles.

(2) Of the members of the Plymouth fauna that are absent from the list, there is little of special interest to mention, these being for the most part essentially littoral species, or those favouring a rocky habitat, or such as are of too infrequent occurrence generally to serve for purposes of comparison. Among the absent species :—

Adamsia polypus (*Sagartia parasitica*) was conspicuously absent despite the frequent occurrence of its host *Eupagurus bernhardus*. On the Eddystone to Start Point Grounds, it is an interesting fact that on gravels Dr. Allen always found this hermit-crab without the anemone, though on the fine sands it was commonly associated with it. It is true the anemone did not occur in the few hauls made on the fine sand of the outer area at about 8 miles, yet its non-occurrence in other hauls suggests that the generally coarse ground of the latter, as in the case of the Eddystone to Start Point gravels, may account for its absence.

Holothuria nigra is generally found at Plymouth in close proximity to rock ledges. Such too was the case in the Eddystone to Start Point fauna where the species occurred only on gravel adjoining the Eddystone rocks. It is not improbable that such rock ledges are still exposed in places on the more distant grounds here dealt with, but there was no clear evidence of this fact afforded by the rock material dredged up at any point.

Antedon bifida, which extends southward to the Mediterranean, and as deep as 100 fathoms (cf. Bell, 65), has not been recorded in the Plymouth fauna outside the Mewstone Ledge.

Echinocardium cordatum occurs on fine sand on the Eddystone Grounds to 35 fathoms, and was obtained occasionally by Dr. Allen on similar ground between the Eddystone and Start Point. It is recorded by Ludwig (72) from southern waters at Marseilles, Naples, and the west coast of Italy, and as deep as 85 fathoms.

Maia squinado is moderately common, especially among rocks in the

Plymouth area, extending as far as the Eddystone Grounds. A few specimens only were obtained by Dr. Allen, on fine sand, between the Eddystone and Start Point.

Corystes cassivelaunus appears to be exclusively associated with deposits of a fine nature, and such as were only met with on the first position at about 8 miles.

With these few species may also be considered certain of those mentioned under the preceding heading, the infrequency of which almost amounts to their absence from the outer fauna. Such are *Suberites carnosus*, *Hydractinia echinata*, *Tubularia sp.*, *Thuiaria articulata*, *Halosydna gelatinosa*, *Capulus hungaricus*, and especially *Portunus depurator* and *Cardium echinatum*.

(3) Of the species hitherto unrecorded from the Plymouth area, *Clathrina primordialis*, as regarded by Haeckel (14), is of almost universal distribution. The remainder are divided as follows, the present records for the English Channel being included in the distribution :—

(A) From Scandinavia through the region of the Shetland Is. and Hebrides to Irish Waters and English Channel.

Sertularella tenella. (Including also Arctic regions, S.W. Atlantic, and Pacific.)

Pectinaria pusilla. (Scandinavia and West of Scotland only.)

Thyone raphanus. (Excluding Scandinavia.)

Tritonofusus propinquus. (Including North Sea.)

Anapagurus hyndmani. (Excluding Scandinavia, and including Channel Is.)

Gobius scorpioides. (Excluding Shetlands and Hebrides.)

(B) The same area, and including the Mediterranean.

Peltogaster sulcatus. (Excluding Shetlands, Hebrides, and Ireland, and including Brazil and Pacific.)

Gonothyrea gracilis. (Including North Sea and S. America.)

(C) The same as (A), including the Bay of Biscay and Azores.

Ditrupa arietina. (Including Mediterranean, Canary Is., and Pacific.)

Inachus leptochirus. (Excluding Scandinavia and Irish Waters, and including Channel Is., Adriatic, and Cape Verde Is.)

Diphasia alata. (Excluding Irish Waters.)

Polyplumaria flabellata. (Excluding Shetlands, Hebrides, and Irish Waters.)

Portunus tuberculatus. (Excluding Scandinavia and Irish Waters, and including Mediterranean.)

(D) From Irish Sea southwards.

Xantho tuberculatus. (Including Bay of Biscay, Coast of Portugal, N.W. African Coast and Cape Verde Is.)

Bathynectes longipes. (Including Channel Is., Mediterranean, Adriatic, and Black Sea). Frequent at Plymouth in recent years.

(E) From English Channel to Azores.

Clathrina contorta. (Including Mediterranean.)

Rhizaxinella elongata. (Including Mediterranean.)

Polymastia agglutinans.

(F) English Channel and Adriatic.

Grantia capillosa.

PORIFERA.

Calcarea.

CLATHRINIDAE, Minchin.

Clathrina coriacea (Fleming).

One small specimen on a dead *Pecten* shell, at Position 33. Depth, 42 fath.

Clathrina primordialis (Haeckel).

At Position	34, one, on shell of *Fusus*, occupied by *Eupagurus*.	Greatest	measurement	9	mm.
,,	38, one, on tube of *Pallasia*	,,	,,	10	,,
,,	45, one, on *Inachus*				
,,	59, two, on dead valve of *Pecten*	,,	,,	10	,,
,,	62, one, on *Volsella*	,,	,,	4	,,

Depth 42–50 fath.

These five small specimens which I have assigned to Haeckel's *Ascetta primordialis* show a good deal of individual variation. The habit of growth is in every case that of a simple network of anastomosing tubes, with a few short oscular processes, forming a thin investment on the object of attachment. The skeleton is composed almost entirely of equiangular triradiates with the component rays often of slightly unequal length. The size of the spicules is fairly uniform in individuals, but between different individuals the average dimensions of the spicular rays range from about 65μ* in length by $6{\cdot}5\mu$ in width at base of ray, to about 110μ in length by 10μ in width. The rays are gradually tapered to a rather sharp or sometimes a somewhat blunt point, the tapering being more strongly marked in the distal half of the ray. In one specimen (No. 240), the rays are more linear and almost *coriacea*-like. In two specimens the skeleton is entirely composed of triradiates.

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* The sign μ is used to designate ·001 mm.

In the three others a few quadriradiates of the same ray-form and size are present, in which the fourth ray is rather smaller but not much shorter than the basal rays. These quadriradiates are so scarce that they might easily escape observation.

Under his "Connexive Varietäten" of *Ascetta primordialis*, and later in the text, Haeckel (14) mentions the existence of this variety with a tendency to form a gastral ray as *Ascaltis primordialis*, though he gives no data concerning its occurrence. In the present case it may be noteworthy that the three specimens possessing quadriradiates were obtained from depths between 42 and 44 fathoms, while those without them were from between 47 and 50 fathoms.

Excepting specimens recorded by Hanitsch (15) from the Liverpool District which he subsequently referred (16) to *C. lacunosa*, the species does not seem to have been recorded north of the Mediterranean.

Clathrina lacunosa (Johnston).

	Length
At Position 34, one, on shell of *Fusus*, growing beside *C. primordialis*,	6 mm.
„ 47, one, on *Scrupocellaria*	„ 5 „
„ 62, one, on *Sertularella*	„ 7 „

Depth, 42–50 fath.

Clathrina contorta (Bowerbank), Minchin (28).

A small patch of spicules undoubtedly belonging to this species was found attached to a surface section of a *Reniera* from Position 58, on or in close proximity to which the specimen would seem to have been growing.

A single quadriradiate spicule, apparently also of this species, occurs similarly on a section of *Raspailia stuposa* from Position 67.

Depth, 49–52 fath.

Though it may appear somewhat hazardous to record the occurrence of this species on the evidence of a few spicules, and in the second case, of a single spicule, I have no doubt, after examining a specimen of *contorta* which Prof. Minchin kindly gave me, concerning the identity of the first record, and little doubt as to the second. In the former case, both of two marked features of *contorta* are very distinct, namely, the very high proportion of quadriradiates, and,—more important,—the long and slender gastral ray of these. In the latter case, the single quadriradiate spicule is of the same form. Monaxons are absent from the fragment from Position 58, a condition which Minchin regards (28, p. 14) as a juvenile feature. It is of interest to note that the two positions lie close to one another, that is, as nearly as the reckoning fixes them, not more than about two miles apart.

The species has been recorded from the Liverpool district by Hanitsch (16, p. 233). An earlier British record by Carter is questioned by Minchin (28, p. 18), who also leaves localities given by Bowerbank (Channel Islands, Scarborough ?) open to doubt, owing to a confusion of species in his material. The natural habitat of *C. contorta* is in the more southern waters: Sark, Luc-sur-mer (Topsent, 35); Roscoff (Topsent, 37; Minchin, 28); Belle Isle (Topsent, 36); Banyuls-sur-mer, extremely abundant (Minchin, 28); Azores, abundant (Topsent, 38); Adriatic (Lendenfeld, 22, pars. (?)—cf. Minchin 28, p. 14). It is apparently one of those species that extend with difficulty within the border line of the British Fauna.

LEUCOSOLENIIDAE, Minchin.

Leucosolenia complicata (Montagu).

Recorded from 24 positions—1, 3, 4, 11–15, 31–37, 40, 43, 45, 49, 51, 52, 58, 59, 64.

Depth, 40–53 fath.

Mostly on Hydroids, *Cellaria* and *Cellepora*, also on shells of *Pecten* and tubes of *Pallasia* and on *Inachus*. At some positions several specimens were obtained, at twelve positions a single one only.

The habit of growth, which varies little among all the specimens obtained, is very different from that of the ordinary shore form. This is a straggling growth, often a confused tangle of slender rambling tubes, in no case exceeding 1 mm. in diameter, usually considerably less, and with no tendency to specialization. Many of the specimens are extremely small. Of the larger ones two especially deserve mention: the first from Position 32, a thickly grown specimen with rambling tubes of less than 1 mm. in diameter, on *Cellepora*, measuring about 35 mm. in extent; the second from Position 37, a very fine specimen of 50 mm. in breadth and 60 mm. in height, forming a tangled shrub-like growth on a shell of *Pecten opercularis*.

SYCETTIDAE, Dendy (13).

Sycon ciliatum (Fabricius).

At Positions 38 (five), 40 (one).

Depth, 44 fath.

I make use of the name *ciliatum* provisionally for the specimens here recorded, on grounds of priority, because after examination of many specimens I am quite unable to separate this form from Haeckel's *Sycandra coronata* as defined by him. In the main they conform more to the latter type than to *ciliatum* in point of the relative length of the gastral ray to that of the facial rays in the gastral quadriradiates; while in regard to the second point used by Haeckel (14), namely the relative width of the monaxons to that of the triradiates and quadriradiates, the character appears to me to be too variable to serve for purposes of distinction. As regards the first character, however, both types are exemplified in the Plymouth forms with every gradation between the two extremes, and further, the short gastral ray of the *ciliatum* type is apparently more characteristic of the in-shore specimens, while the longer corresponding ray of the *coronatum* type commonly occurs in the deeper water. A still more important point arises in the occurrence of at least one instance I have seen, in which both the short and the long gastral ray are present in the same specimen. A careful examination of a larger number of examples is needed to establish the point satisfactorily, but in the meantime I am unable to regard the two forms as specifically distinct.

In three of the six specimens here considered the relative length of the gastral and facial rays is roughly as 7 to 8, 3 to 4, and 1 to 3, severally; while the average relative width of the monaxons and radiates is about $1\frac{1}{2}$–$2\frac{1}{2}$ to 1.

GRANTIDAE, Dendy.

Grantia capillosa (O. Schmidt).

At Positions 1 (one), 3 (one), 4 (three), 36 (one), 37 (two), 49 (one very young), 53 (one very young), 70 (two), 80 (one).

Depth, 40–51 fath.

The genus *Grantia*, to which this species is referred, is here regarded as it is defined by Dendy (13), but with the modification that it does not of necessity exclude the occurrence of the monaxons in bundles at the distal ends of the radial tubes. This reservation would seem alike to involve Dendy's family *Grantidae*, although as defined by him (13) it is not literally restricted on the point. In other respects the species *capillosa* seems to have its proper position in this family and genus, owing to the presence of a distinct dermal cortex covering the distal ends of the radial chambers. The arrangement of the monaxons is rather irregular. For the most part they are grouped in bundles about the ends of the radial chambers, this arrangement being often retained even where the latter are subject to branching, as frequently occurs at the extreme apex. Less frequently they are disposed without much regularity. But they are always large and stout, and usually penetrate for a considerable distance towards the gastral surface. Their disposition is in fact near the border line between the two forms of arrangement which Dendy defines for the Sycettidae and implies for the

Grantidae respectively. Since, however, the arrangement of the monaxons depends, as Dendy observes, on the variation of the canal system, it seems to me inadvisable to limit the latter family too stringently in regard to this character, which may in greater or lesser degree still retain the Syconoid form, as in *capillosa*, after the branching of the chambers has begun and a definite cortex has been assumed.

Mr. C. F. Jenkin first called my attention to this sponge among some unnamed material, and identified it as this species on Haeckel's description. Recently Mr. Kirkpatrick has kindly afforded me the opportunity of examining at the British Museum a co-type of Oscar Schmidt's labelled "*Sycon capillosum*" in his own handwriting, which enables me without doubt to confirm Mr. Jenkin's identification. It will not improbably be found that some confusion has arisen concerning the identity of the species, like many other Calcarea. Particular features which characterize it are: (1) its tendency to interruption of outline, as though through injury, in the region of the osculum, as figured by Scmidt (32, Pl. I, Fig. 6); (2) the shape of the dermal triradiates, approximating somewhat to the remarkable form of those in *Leucandra fistulosa*, though much stouter, with longer basal ray, and smaller unpaired angle than in that species; (3) the slender sub-gastral triradiates with very long tapering basal ray, shorter lateral rays nearly at right angles to it, and often with a fourth ray developed in about the same plane as the latter.

The species was originally recorded by Schmidt from Lebenico in the Adriatic (32, p. 17). Haeckel (14) also records it from Lesina on his own authority and that of Heller. Lendenfeld (22) adds Muggia, Pirano, and Rovigno to these localities. It has also been said to occur at Naples, but as the only slide I have seen so labelled from that locality is undoubtedly of a different species, the latter record seems to need confirmation, and apart from this there is apparently no previous record of its occurrence outside the Adriatic.

Leucandra fistulosa (Johnston).

One specimen at Position 1.

Depth, 40 fath.

Monaxonida.

HADROMERINA, Topsent (40).

TETHYIDAE.*

Tethya lyncurium (Linnaeus.

One specimen at Position 62.

Depth, 50 fath.

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* Dr. Hartmeyer on p. 379 uses this name for an Ascidian family on the ground that the Ascidian genus *Tethyum* is of earlier date than the Sponge genus *Tethya*.

CLIONIDAE.

Cliona sp.

Specimens of *Cliona*, in all cases I believe boring in dead shells of *Pecten*, *Pectunculus*, *Lutraria*, etc., were obtained, sometimes very commonly, at Positions 4, 8, 9, 10, 11, 13, 18, 34, 44, 46, 59.

Depth, 40–49 fath.

The specimens were unfortunately not retained for further examination, and the species must therefore be left unnamed.

POLYMASTIDAE.

Polymastia robusta, Bowerbank.

Six specimens were obtained as single examples at the Positions 8, 14, 51, 55, 77, 80.

Depth, 43–51 fath.

Particulars are as follows, the measurements being made after preservation in spirit:—

At Position 8. Form, depressed hemispheroidal, with fistular processes very numerous. Measurement, 55 × 50 × about 30 mm. in height. On a flat stone. Depth, 43 fath.

,, 14. (Specimen not retained.)

,, 51. Form tending to bulb-shaped, with surface very even, and most of the fistular processes fusing together as one combined outgrowth from the upper surface. Measurement, 35 × 28 × 35 mm. in height. Depth, 43 fath.

,, 55. Fistular processes numerous. Measurement, 50 × 40 × 35 mm. in height. Broken from base.

,, 77. Fistular processes numerous. Measurement, 95 × 75 × 50 mm. in height. Depth, 49 fath.

,, 80. Fragment, torn from an apparently large specimen. Depth, 51 fath.

Polymastia mammillaris (O. F. Müller).

At Position 51. One specimen; forming an investing growth on dead *Pecten* valve, with about a dozen processes. Extent, 23 × 12 mm. Depth, 43 fath.

At Position 58. One specimen; forming an investing growth on dead *Pecten* valve, with base strongly hispid, 50 × 30 mm. in extent, and with seven large smooth fistular processes 20–22 mm. in height. The differentiation between basal and fistular areas exceptionally well shown. Depth, 49 fath.

Polymastia agglutinans, Ridley and Dendy.

Single specimens at Positions 13, 32 or 33 (?), 46, 55, 59.

Depth, 42–49 fath.

The form of the specimens is in all cases that of a depressed, more or less regular spheroidal or ovoid mass from 10 to 25 mm. in horizontal measurement, with from one to eight fistular processes of 6 to 12 mm. in height, radiating from different points of the surface, the body of the sponge forming an investing growth cementing together small pebbles and fragments of shell into a compact mass. This peculiar habit is common to all the specimens, and there seems no doubt of their identity with Ridley and Dendy's *agglutinans* (31), of which the external form and habit is so very similar. Professor Dendy, who kindly examined some slides I sent him and allowed me to see some preparations of his original material, considers that there is no difference of sufficient importance to constitute specific distinction. The main characters of the skeleton are almost identically the same, though in the dimensions of the spicules there is a considerable difference. Ridley and Dendy's measurements for the large tylostyli are 1200 μ by 15·7 μ; for the microsclera, 175 μ by 4 μ. In the specimens here considered the megasclera average from 450 to 500 μ, and sometimes exceed 700 μ, but in no case have I seen one reaching 800 μ. The width of the largest is 14·8 μ. The microsclera average about 140 μ by 3·7 μ. The difference may be a local one. The megasclera are rather more like those of *robusta* than those of *mammillaris*. The microsclera are like those of *mammillaris*, but with much more pronounced heads.

The *Challenger* specimens (two) were taken off the Azores in 450 fath. on volcanic mud.

SUBERITIDAE.

Ficulina ficus (Linnaeus).

Most of the specimens of this sponge obtained were of the massive carcinoecious form, and generally occupied by a Pagurid, but none were of large size. Occasionally, as where stated in the following particulars, they occurred in the earlier stage of these investments on shells of molluscs.

At Position	1, one.	Greatest measurement	20 mm.
„	7, one.	„ „	28 „
„	34, one.	Small.	
„	35, two.	Greatest measurement	23, 35 mm.
„	37, one.	„ „	16 mm.
„	43, one.	„ „	22 „
„	52, eight.	„ „	16, 17, 22, 24 mm., and four, thinly investing shells of *Natica*, *Trochus*, etc.
„	59, four.	„ „	15, 19, 20, 26 mm.
„	60, one.	„ „	12 mm., investing shell of small Gastropod.

Depth, 40–49 fath.

In all of three specimens closely examined, namely those from Positions 7, 43, and 60, the centrotylote microsclera are abundant but extremely variable in size and form.

Much confusion has arisen about the identity of this species, which has frequently been referred to as *Suberites domuncula*, a species which apparently does not occur in the British fauna. For a discussion of the species with full synonymy, see Topsent's valuable account (41, p. 203). The extremely large growth often attained by the species on the inner grounds inside the breakwater seems never to occur in the deeper water, the difference being apparently due to food-supply.

Suberites carnosus (Johnston).

At Position 9. One small detached specimen. Greatest measurement 5 mm.
„ 32 or 33 (?). One small specimen of ovoid form growing on the basal portion of *Polymastia agglutinans*. Greatest measurement 10 mm.

Depth, 42 fath.

Rhizaxinella elongata (R. and D.), Topsent.

A single specimen, evidently belonging to this species, was obtained at Position 38, in 44 fathoms. Some uncertainty was felt as to its identity owing to the presence of an important internal character to which no allusion has been made in records of the species. This is the possession of a series of longitudinal belts of spicules in the form of a broken hollow cylinder surrounding and distinct from the axial core. It is difficult to understand that no mention should be made of a character that is definitely shown in the longitudinal and the transverse sections, but in all other respects it conforms so closely with the descriptions of *elongata* that I can only regard it as the same species, and conclude that the point referred to has been overlooked.

The specimen forms a slightly bent column of 60 mm. in height, widening gradually in diameter from 5 mm. at base to 8 mm. near the middle, beyond which it is sub-cylindrical, with the apex rounded. The colour in spirit is pale yellowish white. There are numerous small oscula scattered at irregular intervals over a great part of the surface, without any particular reference to the apex. The specimen was broken from its attachment, but two small rootlets are preserved in connection with a rounded base. The texture is very tough and compact.

The skeleton consists of a very compact central axial core of stylote spicules with a quantity of spongin, surrounded by a clear area, beyond which is a ring of spicular belts running parallel to the axial core, the component belts following a spiral course. In the transverse section these belts are marked off from one another by slender strands of few spicules that radiate sub-spirally outwards and upwards from the axial core, across the clear area, and through the belts to the surface. Similarly, spicular strands separate off independently from the outer side of the belts themselves and branch in a spreading fashion on their way to the surface, beyond which many of the spicules extend. At the surface they combine with innumerable radiating fasciculi of smaller and shorter styli, to form the dermal hispidation, which has the form of a closely approximating series of defensive brushes.

The spicules of the longitudinal belts and their branches, and those of the axial core, are slender styli, often slightly curved, with simple rounded base, sometimes faintly tylote, and with sharp tapering points. They range from 900 to 1600 μ (averaging 1300 μ) in length, and from 7 to 11 μ (averaging 9 μ) in width. The spicules of the dermal fasciculi, which are also present in small numbers, scattered between the longitudinal belts and the surface, are styli of 200 to 440 μ (averaging 280 μ) in length, and 2 to 6·5 μ (averaging 4·5 μ) in width. Many of them are simple, but a large number—perhaps the majority—are strongly tylote, and usually with a second ring-like expansion beyond the basal one, as in the spicules, e.g., of *Suberites carnosus.* The bases of these dermal tylostyli are extremely like those of the latter species, and in the vertical view of the outer surface there is a striking similarity between the two sponges.

The noteworthy points of difference from Ridley and Dendy's original description of *Suberites elongatus* (31) are, besides that referred to, the more slender form of the large styli, and the absence of a true pedicel. In regard to the last point, several specimens of the same species were collected during a subsequent cruise at a more distant and deeper position in the Channel. These all show the typical slender pedicellate growth, characteristic of *elongata*, while the spiculation of two specimens examined shows no appreciable difference from the foregoing description, except that the numerical proportion of tylote to simple styli in the dermal fasciculi is lower.

The species has been recorded from the Bay of Biscay: one, in 248 m. (Topsent, 38); one, in 180 m. (Topsent, in 10); Coast of Roussillon, two, in 94 m. (Topsent, in 10); Azores, eight, in 450 fath. (Ridley and Dendy, 31).

HALICHONDRINA, Vosmaer.

HAPLOSCLERIDAE, Topsent.

CHALININAE, Ridley and Dendy.

Siphonochalina montagui (Bowerbank)?

At Position 46, one specimen, broken from attachment—possibly *Lepralia;* forming an erect compact growth of irregularly inosculating, more or less tubular branches, the whole somewhat depressed laterally and with some external resemblance to certain broadly expanded forms of *Alcyonidium gelatinosum;* with several oscula raised on low prominences of 2–4 mm. in diameter. Height, 65 mm. Width, 62 mm.

„ 68, one broken specimen, on *Lepralia foliosa;* with massive basal portion, 50 × 40 mm. in extent, tunnelled by tubular ramifications and surmounted by at least one large tubular process, 60 mm. in height by 25 mm. in diameter, with an osculum at summit, 9 mm. in diameter.

Depth, 47–52 fath.

The texture of the first specimen is compact and rigid, and similar in general appearance to Bowerbank's figures for the species; that of the second, except for a certain rigidity about the base, is quite the opposite. In external characters the two specimens are quite distinct, but the internal structure of both, including the form and dimensions of the spicules, shows so little difference that there seems no justification for separating them. The skeleton is composed of two distinct elements:—

(*a*) A primary interlacing network, ramifying through all parts of the sponge, of very clearly defined (? keratose) fibres, each composed of bundles of fibrillae, and commonly enclosing a variable number of oxeote spicules running longitudinally within them. Sometimes the enclosed spicules are very numerous, but often they are entirely absent from the fibres. In a tangential section of one specimen some of the larger fibres attain, even close to the surface, a thickness of as much as 100 μ. In a tubular portion of the same specimen a thick fibre traverses the centre of the tube, throwing off subdividing branches to the periphery. Oxea occur likewise, though with extreme scarcity in this axial fibre and even in its slender branches to the wall of the tube.

(*b*) A secondary *Reniera*-like, and to some extent regularly disposed network of unispicular meshes, with a decided tendency to assume in the main lines an outwardly radiating direction from interior to surface. This appears to be quite independent of the primary network. The ends of the spicules are cemented together with deposits of spongin, usually to a distance of about 20 μ down the shaft from the point. The spicules composing this network are oxea of fairly uniform dimensions averaging about 90–100 μ in length by 5 μ in width. With them are associated, irregularly disposed, smaller oxea of about the same length, and half or less than half the width, and very fine hairlike oxea of about 50–60 μ by 1 μ.

The spicules of the primary skeleton are similar in form and dimensions to those of the secondary skeleton, and include the slender hairlike forms of the latter. The dimensions of the large oxea shown by Bowerbank's figure for the species are rather larger—about 124 μ by 6·5 μ.

The tubular tendency of the sponge seems to place the species in the genus *Siphonochalina* as defined by Schmidt (33, p. 7), and by Ridley and Dendy (31, p. 29); but the remarkably composite structure of the fibres of the primary skeleton, very different from the clear fibres of, e.g., *Chalina oculata*, leaves some doubt as to its identity with the species to which it is here assigned, or indeed of its true position among the Chalininae. The fibrillae of which the fibres are composed have themselves individually the form of a string of beads, each bead contributing internally a separate rod-shaped element to form a centrally-placed strand running along the string. Loisel * describes an almost identically similar condition in certain species of *Reniera*, so called. But in the present examples I find no evidence of the bead-like cells which secrete the elemental rods ultimately breaking down, as Loisel describes, so as to have a simple continuous strand. They appear, on the contrary, to be permanent, while the contained rods remain separated at their ends from one another by a narrow interval between adjacent beads. These fibrillae, and their contained rods in particular, give a deeper reaction to stains like eosin and methylene blue than the deposits of spongin about the ordinary skeleton, and this fact, coupled with that of the independence of the two skeletons, suggests that the substance of the primary skeleton may be of a slightly different constitution from that of true spongin.

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* *Contribution à l'histophysiologie des éponges.* Journ. de l'anat. et de la physiol., XXXIV. 1898.

RENIERINAE, Ridley and Dendy.

Halichondria sp.

A fragment of a *Halichondria*, too small for determination, occurred on *Inachus dorsettensis* at Position 3.

Depth, 40 fath.

The skeleton is very irregular, with a confused and broken network of loosely constructed spicular bundles forming the main lines. It is chiefly composed of large oxea 250–350 μ in length and 7–10 μ in width, together with smaller oxea 200–250 μ in length and 2–3 μ in width, not very numerous; and thinly scattered very slender oxea, 100–200 μ in length and 1 μ in width. The spiculation approximates nearly to that of Bowerbank's *H. caduca*.

Reniera, Nardo.

Without yet having had an opportunity of examining any of Bowerbank's original specimens of this difficult genus, the species here considered are named so far as possible from his descriptions and figures alone.

Reniera indistincta (Bowerbank).

At Position 3, two specimens, each forming a shallow investing growth on *Inachus*.

,, 12, one specimen, forming an irregular growth on a *Pecten* valve, with tubular processes; 10 mm. in extent.

,, 14, two specimens, one forming a shallow investing growth on *Inachus*, the other an irregular mass, 30 × 20 mm. in extent, intermingled with Hydroids and forming tumulous elevations.

,, 25, one specimen, with basal attachment 15 mm. in diameter, and one lateral prominence, surmounted by a tubular process 15 mm. in height; on a *Chaetopterus* tube.

Depth, 40–46 fath.

The large oxea range from about 140 to 170 μ in length by 5–6 μ in width, as against dimensions shown by Bowerbank of about 158 μ by 4 μ. With these occur numerous more slender oxea, 120–140 μ by 2 μ, and also slender hair-like oxea scattered irregularly, averaging about 100 μ by 1 μ or less.

Reniera sp. (A.).

At Position 56, one specimen, forming a small growth on *Inachus leptochirus.*

Depth, 49 fath.

Skeleton mostly unispicular and very similar to that of the preceding, but the main skeleton spicules are longer and more slender in proportion, ranging from 150 to 200 μ by 4 to 5 μ. Smaller oxea and fine hair-like oxea occur as in the last species.

Reniera sp. (B.).

At Position 6, one specimen, forming an irregular massive growth on stems of *Antennularia,* etc.

Depth, 42 fath.

Skeleton almost entirely unispicular, but with the reticulation very irregular. Large oxea of much the same length, 150–170 μ, as in specimens referred to *indistincta*, but much wider, 7–8 μ, and remarkably uniform in size. Slender hair-like oxea scarce.

Reniera pygmaea (Bowerbank).

At Position 40, one specimen growing from dead base of *Antennularia.*

Depth, 44 fath.

The specimen forms a short bifurcated growth of about 25 mm. in height, and 6 mm. in diameter of branches, arising from a narrow stem. In appearance and general texture it bears a certain resemblance to a small *Chalina oculata*, as Bowerbank remarks of specimens before him. A comparatively large quantity of spongin occurs at the ends of the spicules, which at times seem almost entirely invested by a thin layer of it. The oxea of the main skeleton, averaging 110 by 5 μ, are more slender than Bowerbank shows for *pygmaea* as 118 by 7 μ. A number of more slender oxea occur in addition.

Reniera densa (Bowerbank).

At Position 1, one specimen, forming an irregular mass of dense texture about Hydroids. Height 25 mm.

Depth, 40 fath.

The radiating lines of the main skeleton are distinct and largely multispiculous. The remainder of the reticulum is somewhat irregular. Spicules exceptionally uniform, with an almost entire absence of slender forms. Dimensions from 120 by 6 μ to 140 by 9 μ. The measurements shown by Bowerbank are 130–145 μ by 10 μ.

Reniera sp. (C.).

At Position 62, one specimen.

Depth, 50 fath.

The specimen is a fragment torn from its base, consisting of a thimble-shaped process, 25 mm. in height by 17 mm. in width, with an osculum of 5 mm. in diameter at the summit. Texture soft and flexible. Skeleton rather irregular, with spongin very little developed. Average measurement of large oxea about 190–200 μ by 8–10 μ. A few styli of about the same width but a little shorter are intermixed abnormally, also very occasionally short smooth strongyla of the same width. Slender oxea rather numerous and scattered, ranging in size from about 100 by 2 μ to 150 by 3 μ.

POECILOSCLERIDAE, Topsent.

ESPERELLINAE, Ridley and Dendy.

Esperiopsis paupera (Bowerbank).

At Position 3, one specimen, forming an irregular growth on *Sertularella gayi*. Length 25 mm.
„ 33, one small specimen on dead *Pecten* shell, 11 mm. by 5 mm., with one osculum, with ova at base.
„ 36, one specimen, forming a small column, 9 mm. in height, with narrow spreading base. On *Porella compressa*.
„ 38, one specimen, an irregular creeping growth, about 10 mm. by 4 mm. in extent, with a free raised lobe. On *Pallasia* tube.
„ 49, small patches on *Inachus leptochirus*.

Depth, 40–47 fath.

Ridley and Dendy (31) have included the *Isodictya paupera* of Bowerbank, with a query, among the synonyms of his *I. edwardsi*, and it may be that the two forms are merely varieties of the same species. I have retained, however, the former name for the five specimens here considered, because in no case do the main skeleton spicules approximate to those shown by Bowerbank for *I. edwardsi*, while their difference from those of *paupera* is inappreciable. Excepting that from

Position 33, in which there is a small raised osculum and the texture is rather more compact, the specimens have all the same meagre straggling habit of growth, with loose attachment to their base. The skeleton has a more or less regular arrangement of compact multispicular lines following a sinuous course from base to surface, with spicules connecting these largely at right angles in such a way as often to enclose with the main lines a series of rough rectangles, in the vertical section. The spicular dimensions are very variable. The larger main skeleton styli average about 180–200 μ in length, by 6–7 μ in width. In the specimen from Position 36, the average width is lower —about 5 μ. There is no clear line of separation between these and the secondary styli, averaging about the same length and half the width. Very slender, irregularly disposed, hair-like styli of 120 to 150 μ by 1 μ, or less than 1 μ, and isochelae averaging 18 to 20 μ in length, are both usually very numerous. In the specimen from Position 49 both are comparatively scarce. Except in this last-named example abnormalities are frequent, in the form of medial bulb-like swellings in the spicules. Sometimes these occur more especially in the intermediate-sized styli; often rather more so in those of the main skeleton. The tendency is very pronounced in the specimen from Position 38, in which a considerable proportion of the larger styli show this abnormality, and occasionally two such swellings appear in the shaft. In this specimen a large oxeote spicule occurs in one section, with the same swelling in the centre.

Esperiopsis sp.

At Position 5, one specimen, forming large nodulous growths, almost entirely covering a large specimen of *Inachus dorsettensis;* with two large oscula, 5 mm. in diameter, raised on prominences, and numerous small ones, 1 to 2 mm. in diameter, scattered over the surface.

Depth, 42 fath.

While very distinct in its external form and more compact texture from the preceding species, the internal structure and spiculation of this specimen differ little from it. The main lines of the skeleton have nearly the same arrangement. The chief difference lies in the dimensions of the spicules, and this is not very considerable. The larger styli average about 150 μ by 7 μ; intermediate styli, 150 μ by 2–3 μ; hair-like styli, occasionally centrotylote, 100–150 μ in length, not very numerous; isochelae of the same form and size as in the last species, very scarce. But for Bowerbank's remark concerning the great irregularity of the main skeleton of *imitata*, which can hardly be applied to this specimen, it would seem to approximate closely to that species.

Esperella sp.

At Position 72, one specimen, forming a thin even investment on one valve of living *Pecten opercularis.*

Depth, 43 fath.

I find no described species to which this specimen seems referable. The main lines of the skeleton are composed of smooth styli, decidedly but not strongly clavate; fairly uniform in size, and averaging about 240 μ by 4 μ. These arise as numerous loose fasciculi, composed of about a dozen spicules, which subdivide and occasionally anastomose in rough curves, and split up internally or at the surface in fan-like extensions. Irregularly disposed styli in the interspaces are not very numerous. The microsclera are of five forms: (1) large palmate anisochelae averaging about 30 μ in length, arranged mostly in rosettes; (2) large bidentate anisochelae of same size, often associated in rosettes with the preceding, and possibly an immature form of them; (3) small bidentate anisochelae, variable in size, but averaging about 12 μ in length, mostly scattered, not very numerous; (4) sigmata, about 30 μ (one only was observed in a preparation lying in an unsuitable plane for measurement); (5) very slender toxa about 130 μ in length. The toxa are chiefly associated with embryos at the base of the sponge, and one pole of one of these embryos is covered with rosettes of the third form of anisochelae as close to one another as they can lie. It is quite possible that this specimen is an irregular form of Bowerbank's *Raphiodesma floreum.* In habit of growth and in most of its characters it strongly resembles his description of that species. The noteworthy differences are that in the latter Bowerbank makes no reference to the small anisochelae as tension spicula, but refers to numerous small sigmata in their place which do not seem to occur at all in this specimen. That he should make no mention of toxa is perhaps not surprising, since they scarcely seem to exist in the specimen apart from the embryos, whatever their function in this respect may be. Very fine styli of about 140 μ in length are likewise associated with these embryos, and almost exclusively so.

Desmacidon fruticosus (Montagu).

At Position 7, one, on valve of *Pectunculus glycimeris.* Small sigmata very numerous.
„ „ one large specimen. Small sigmata scarce.
„ 58, two detached specimens; the largest 70 mm. in height. Sigmata and chelae very scarce.

At Position 59, one very young specimen, 7 mm. in diameter by 4 mm. in height. On dead valve of *Pecten opercularis.* Sigmata numerous. Several of the slender oxea were observed to be strongly centrotylote.
,, vii., one, of irregular form, measuring 100 by 25 mm. Sigmata numerous.
,, 77, one large specimen.

Other examples, not retained, occurred at Positions 8, 14, 34, 43, 44, 68, 76 (a few), 78 (a few).

Depth, 42–52 fath.

DENDORICINAE, Topsent.

Dendoryx incrustans (Esper).

At Positions 3 (five), 4 (two), 13 (one), 14 (one), 43 (one), 52 (one), 60 (one), 64 (one).

Depth, 40–53 fath.

The specimens varied in habit from that of a thin investment on *Inachus*, *Cellaria*, etc., to that of an irregular more or less massive growth on Hydroids and other objects, the largest measuring 65 mm. in height by 70 mm. in width.

Dendoryx (Iophon) nigricans (Bowerbank).

At Positions 46 (one), 59 (one).

Depth, 47–49 fath.

Ridley and Dendy (31) united Bowerbank's four species *Halichondria pattersoni*, *H. scandens*, *H. hyndmani*, and *H. nigricans*, as varieties of the one species *pattersoni*, under the genus *Iophon*, which is distinguished by the presence of bipocilli as microsclera. Topsent (31) objects to this, and particularly to the inclusion of *pattersoni*, on the grounds that Bowerbank makes no mention of bipocilli occurring in that species. I follow Topsent in treating *Iophon* as a sub-genus of *Dendoryx*, and refer the two specimens here considered to *nigricans* as more nearly in conformity with Bowerbank's description of that form, though in some particulars they vary from it.

The specimen from Position 46 is a large one, of very irregular, partly massive, partly branching and anastomosing growth, evidently attached to *Lepralia foliosa* and partly intermingled with a few hydroids. The dimensions are about 140 mm. by 100 mm., the latter probably having represented the height of the specimen, which was broken. That from Position 59 formed an irregular spreading growth on a fragment of a *Mactra* valve, measuring 25 by 20 mm. in extent. Both examples are of a soft spongy texture, with irregular corrugated surface, and dark purplish brown in colour.

The styli of the main skeleton are faintly, sometimes strongly spined, chiefly at the base, and the majority are curved. The average length is in the first specimen about 200 μ; in the second about 190 μ. In neither case does it exceed 230 μ, which is a good deal less than Bowerbank's figure shows. Many of the spicules are slightly wider in the middle. The width is very variable, ranging from 4 to 7 μ, and averaging about 6·5 μ.

The tylota average in the first specimen about 205 μ by 4·5 μ, in the second about 215 μ by 5 μ. The ends are feebly expanded or often simple and faintly spined. The intermediate portion is smooth, with the central part usually the widest.

Extremely slender hair-like styli often curved, of about 150 μ in length, irregularly dispersed, are numerous.

Anisochelae very scarce; length 22 μ.

Only very few bipocilli were observed after careful searching. These measure about 7 μ in length, and are of the form figured by Bowerbank for the species.

Dendoryx robertsoni (Bowerbank).

At Position 78, one specimen. Form massive, irregular, 70 × 50 × 40 mm. in height. Broken from attachment—probably a stone.

Depth, 49 fath.

Both in external form and skeleton, the specimen closely agrees with Bowerbank's description of the species.

Megasclera. Spined styli averaging about 185 μ in length, and mostly from 4 to 7 μ in width. Tylota with ends sometimes bluntly pointed, of about the same average length, and 4·5 μ in width at centre of shaft.

Microsclera. Sigmata, 33 μ; large isochelae, 33 μ; small isochelae, 18 μ. None of the microsclera are very numerous.

Dendoryx dujardini (Johnston).

At Position 49, one specimen, thinly investing a living valve of *Pecten opercularis.*
„ 67, one specimen, forming small patches on *Inachus leptochirus;* with a quantity of brown pigment present.

Depth, 47–52 fath.

The skeleton has a rough arrangement of sinuous multispicular lines with a large number of isolated spicules, irregularly dispersed between them, and supporting a somewhat dense and very confused dermal network. The strongyla, of which the ends are often faintly tylote, mostly range in the first specimen from 190 μ to 220 μ in length, by about 3 μ in width. In the second specimen they are longer and much more slender on the average, about 220 by 2 μ. Spined tylostyli are extremely scarce, one only, in fact, having been observed in one specimen, and none in the other. This spicule has the characteristic prominent head, and measures about 92 μ. Embryos are present in both specimens; several in one case, irregularly located. In a few instances the tylota have a prominent bulbous swelling at the centre, or some way from one end. The proportions of the spicules seem very instable in this species. In a specimen obtained from within two miles of the Eddystone Lighthouse they average about 185 μ (many falling to 120 μ) by 1·5 μ, or less, while in a preparation of another specimen only a few are to be found at all.

BUBARINAE, Topsent.

Bubaris vermiculata (Bowerbank).

At Position 15 (four), 38, 43, 44 (two), 47 (five), 59, 60.

Depth, 44–49 fath.

The examples have all the form of a thin cementing investment about dead valves and fragments of *Pecten*, *Cardium*, *Lima*, etc., and larger or smaller pebbles. The maximum extent ranges from 9 to 45 mm.

ECTYONINAE, Ridley and Dendy.

Stylostichon plumosum (Montagu).

At Position 10, one specimen, forming an irregular growth coating tubes of *Pallasia murata*, etc. Measurement, 85 × 45 × 25 mm.

„ 49, one specimen, forming a nodulous investing growth, cementing together shell fragments and gravel, with *Cellaria*, etc. Measurement, 50 × 33 × 20 mm.

Depth, 42–47 fath.

Acanthostyli: Large, 180–280 μ (average about 226 μ) in length, and 5·5–7·4 μ (average about 7·2 μ) in width. *Small*, 85–160 μ (average about 120 μ) in length, and 5·5–7·4 μ (average about 6·8 μ) in width. There is no distinct line of separation between these and the preceding.

Oxea. Straight, suddenly pointed: 185–207 μ (average 195 μ) in length, and 3·5–5·5 μ (average 5 μ) in width.

Isochelae. Mostly bidentate, but many tridentate: 14·5–18·5 μ.

Bowerbank mentions this coating variety, thinly investing stones, from the Diamond Grounds, off Hastings.

AXINELLIDAE, Ridley and Dendy.

Raspailia hispida (Montagu).

Specimens referred to this species occurred at Positions 3, 4 (two), 7, 8, 33, 38, 40, 43, 52, 53, and 80 (two).

Depth, 40–51 fath.

Seven other specimens were obtained at positions of which the record was lost, but which probably all lay between ten and twenty miles to the south-westward of the Eddystone.

Among the numerous and often considerable differences in external form and spiculation of these several examples, there appears to be no single character that may be regarded as affording safe grounds for separating them. In the form and proportions of the spicules especially, the extent of variation is so great, not only between one individual and another but often in the same individual, that careful examination has led me to include them all together as variations of the *Dictyocylindrus hispidus* of Bowerbank. A single specimen has the external form on which Bowerbank founded a separate species under the name of *Dictyocylindrus rectangulus*, but there is nothing in the spiculation to justify its separation from several examples having the simple, upright branching habit of growth throughout. Three specimens are of the free form (one being the *rectangulus* type referred to), branching at one or both ends, as figured by Bowerbank for *D. hispidus*, and apparently referred to by Montagu. Others have a similarly slender growth with few branches from their base of attachment. In another specimen three branches arise almost simultaneously from a common stem about 8 cm. from the base of attachment. In some others the growth is much stouter, and roughly dichotomous. In most cases growth extends in about the same vertical plane. The greatest length is attained in a free form of 36 cm. Four specimens are deeply pigmented (with a dark ruddy brown colour, in spirit); the others were, from recollection, pale or brighter yellow in life.

The axial skeleton is somewhat loose and irregular, with a large number of the spicules crossing one another at varying angles, and often lying nearly or quite at right angles to the main axis. From it, with their bases often deeply placed, spicules arise separately or in indefinite groups and nearly at right angles outwards, and extend far beyond the surface. Most of the latter are styli, but some strongyla occur among them. They are generally very similar in size to those of the axial skeleton, but often rather stouter. Sometimes their points are directed inwards. At or near the surface many of them are surrounded by a radiating fasciculus of small slender styli of about

400–450 μ in length by 3 μ in width. A varying number of similar slender styli and oxea, of the same dimensions and larger, run longitudinally or irregularly through the column, and especially close below the surface. These are occasionally strongly curved and almost sigmatoid, and often occur in pairs. The axial megasclera are extremely variable in form and dimensions. They consist mainly of styli, usually with strongyla and oxea intermixed in greater or lesser proportion.

Styli often much curved, rarely (specimen from Position 40) very sharply pointed, usually bluntly pointed or even rounded, leading to the strongylous form. Base generally simple, often more or less tylote, or, in individual spicules in certain specimens, very strongly so. Dimensions, 700–1900 μ in length and 11–22 μ in width; averages in different specimens, 1100–1700 μ in length and 14–17 μ in width, respectively.

Strongyla were not observed in specimens from 38, 40, 43, and 53; scarce in those from 4, 7, and 8; common or numerous in those from 3, 4, 33, 52, 77, and 80. They vary from short stout forms of 180–450 μ in length and as much as 33 μ in width to more slender forms of 800–1200 μ in length and 15–18 μ in width. The short stumpy forms were observed only in specimens from 3, 4, 52, 77, and in one of those of doubtful position, and appear to be often associated with the more slender habit of growth. The fact that Bowerbank does not mention the occurrence of strongyla in his description of *R. hispida* cannot, I think, be considered of sufficient importance to exclude from that species specimens which have them, often in large numbers. It is inconceivable that Montagu's original specimens, including the familiar type he figures (29, Pl. V), obtained by trawlers off the Devon coast, were distinct from some specimens here considered of identically similar habit, in which numerous strongyla occur.

Oxea were not observed or scarce in specimens from 3, 4, 8, 40, 53, and 80; numerous or very numerous, often strongly curved, in those from 7, 8, 33, 43, and 77. In number they sometimes nearly equal or exceed that of the styli. Their dimensions range from 700 to 1200 μ in length and 8 to 19 μ (average about 15 μ) in width.

Acanthostyli were not observed or scarce in specimens from 3, 4, 7, 8, 33, 40, and 80; numerous or very numerous in those from 4, 38, 43, 52, and 53. Length, generally 85 to 100 μ, occasionally reaching 140 μ. Width at base (not including basal swelling when present), 5 to 7 μ.

Raspailia ramosa (Montagu).

Single specimens at Positions 46, 49, 67, 77.

Depth, 47–52 fath.

The four examples which I assign to this species, though closely allied to some specimens of the preceding species in general characters, are distinct from them in certain details, and notably in the shape of the acanthostyli, which with comparatively rare exceptions are much longer, more slender, and more finely pointed. In external form, two of the specimens rather closely resemble that of Ridley and Dendy's figure of *Dendropsis bidentifera* (30); one, from Position 46, is of slender, straggling, long-branched growth; the fourth occupies an intermediate position between these two forms. One is lightly, the others deeply pigmented, with a rufous-brown colour in spirit.

The main features of the spiculation are very similar to those described for the preceding species, but the spicules of the axial column are rather more irregularly disposed. The large *styli* are comparatively stout. These range from 800 to 1600 μ in length, with an average of about 1100 μ (higher or lower in different examples), and from 11 to 18 μ, with an average of about 16 μ, in width. *Strongyla* are present in specimens from 46 and 67; length, 450 to 1000 μ (average about 650 μ); width, 16 to 22 μ (average about 19 μ). Round-ended styli occur in the specimen from 49, but true strongyla were not observed in this or the specimen from 77. *Oxea* occur in the specimen from 46 only; length 800 to 1100 μ; width 15 μ.

Very slender styli and oxea occur, scattered more or less numerously through the column, and commonly in pairs or small groups, as in the preceding species. There is some difficulty in distinguishing many of these paired forms from what appear to be elements in process of constructing the larger styli.

Acanthostyli longer, more slender, and more sharply pointed than in the preceding species. Length, 95 to 166 μ (average about 129 μ). Width, 4·5 to 6·5 μ (average 5 μ).

Acanthoxea occur in very small numbers, intermixed with the acanthostyli, in specimens from 46 and 49, but I have been unable to find them in the other two. The example from 49 is one of the two already referred to as rather closely resembling Ridley and Dendy's figure of *Dendropsis bidentifera*. It is an interesting fact that this species is especially characterized by the presence of small acanthoxea, and the genus *Dendropsis* was founded to receive it. In the present case, however, I can only regard these spicules as abnormalities of the acanthostyli, which vastly outnumber them. They are nearly always centrotylote, and in one instance observed the tylote expansion is elongate with a distinct constriction in the centre of it. Length, 118 to 225 μ (average 187 μ). Width, not including expansion, 4·5 to 5·5 μ (average 5 μ).

Raspailia stuposa (Montagu).

Single specimens at Positions 31, 32, 51, 53, 60, 67, 80.

Depth, 40–51 fath.

The smallest example is 22 mm., the largest 50 mm., in height. The growth is fairly uniform and symmetrical, the branches spreading roughly in the same plane, and being much compressed laterally in a plane at right angles to that of the growth. Pigmentation (in life dark brown) is absent in specimens from Positions 51, 53, and 60; moderately strong in those from 31 and 80; very deep, giving an almost black appearance superficially, in those from 32 and 67.

The stellate microsclera are very abundant in all the specimens.

COELENTERATA.

HYDROMEDUSAE.

CLAVIDAE.

Merona cornucopiae, Norman.

On *Dentalium entalis* at Positions 1 (common); 11 (two; one with gonophores); 36 (one); and on *Pectunculus glycimeris* at Positions 46 (one), and 51 (one).

Depth, 40–43 fath.

HYDRACTINIIDAE.

Hydractinia echinata, Fleming.

One colony on a young shell of *Fusus islandicus* at Position 52.

Depth, 43 fath.

PODOCORYNIDAE.

Podocoryne (?) sp.

At Position 49, in 47 fathoms, a small Hydroid colony was found growing on a *Macropodia*, which, though lacking in certain adult characters of this genus, is provisionally recorded under it because there seems to be no other genus with which it can be associated.

The colony consists of a large number of simple short polypes arising directly from a hydrorhiza, which is composed of a close network of anastomosing tubes. I have not been able to detect any trace of a chitinous perisarc investing the hydrorhiza, or any cup-like processes from the hydrorhiza surrounding the bases of the hydranths. The hydranths, which number about 200, are closely crowded together, and arise from a somewhat constricted base in direct continuation with the simple tubular stolon. They were not examined in life, but in their semi-contracted condition in spirit the largest do not exceed 1·5 mm. in height, while the majority are considerably smaller than this. The form of the more extended ones is nearly cylindrical with a width equal to about one-fourth or one-fifth of the height, with the apical portion somewhat claviform and surmounted by a rounded conical hypostome. A short way below the hypostome there is a single row, or, perhaps more correctly, a double row of simple tentacles, which often show a distinct arrangement of large and small ones alternately, the smaller ones apparently arising slightly below the origin of the others. The tentacles number from eight to twelve. There is no gonosome present in the colony.

EUDENDRIIDAE.

Eudendrium capillare, Alder.

Small colonies at Positions 3, 6, 10, 11, 38, 40, 49, 59, 80. On *Cellaria* and Hydroid stems and *Chaetopterus* tubes.

Depth, 40–51 fath.

Eudendrium sp.

A very small species, much like the preceding, but of rather stouter habit, and perhaps distinct from it, was obtained at Positions 14, 32, 40, and 53. On *Cellaria* and Hydroid stems.

Depth, 42–46 fath.

Eudendrium ramosum (Linn).

Several small colonies at Position 34, and four colonies, from ½ to 1 inch in height, on a fragment of a bivalve shell at Position 56.

Depth, 42–49 fath.

BOUGAINVILLIIDAE.

Bougainvillia ramosa (van Beneden) ?

Small branching colonies of a *Bougainvillia*, probably referable to this species, but with none bearing gonophores, were obtained at Position 5, on *Inachus dorsettensis*, and at Positions 14, 35, and 59, on Hydroids and *Cellaria*.

Depth, 43–49 fath.

TUBULARIIDAE.

Tubularia sp.

A single small *Tubularia*, which was not identified, was taken at Position 1.

Depth, 40 fath.

CAMPANULARIIDAE.

Clytia johnstoni (Alder).

Only observed at Position 5, on *Inachus dorsettensis*.

Depth, 42 fath.

Campanularia flexuosa (Hincks).

At Positions 14, 31, 32, 35, 38, 43, 49, 51, 59, 60, 62, 80. Chiefly on *Cellaria*, also on other Hydroids, and one on a shell fragment. Mostly small colonies, not exceeding 8 mm. in height. The largest occurred at Position 62, on a small shell fragment with several branching growths arising from the basal stolon. Specimens from 32, 51, and 62 bore gonangia. A few of the others incline to the more slender form of *angulata*, but there seems little doubt that they all belong to the same species.

Depth, 40–51 fath.

Campanularia hincksi, Alder.

At Positions 3, 4, 7, 12, 13, 31, 32, 33, 34, 35, 38, 42, 43, 45, 47, 49, 53, 56, 60, 62, 80.

Depth, 40–51 fath.

On Hydroids, *Cellaria*, dead shells, and one on *Scalpellum*. A single colony only occurred with gonangia at Position 62.

Campanularia verticillata (Linnaeus).

One colony at Position 3, on *Cellaria*.

Depth, 40 fath.

Campanularia raridentata, Alder.

Scattered polyps, apparently identical with this species, were observed at Positions 4, 12, 13, and 49.

Depth, 40–47 fath.

Gonothyrea gracilis (Sars).

At Positions, 14, 33, 35, 51, 58, 59, 62.

Depth, 42–50 fath.

On *Cellaria*, occurring in most cases as single scattered polyps, but occasionally of erect branching form. Gonangia were borne on specimens from Positions 14, 35, and 58.

This species which has not hitherto been recorded in the Plymouth fauna has a wide distribution :—Norway, Baltic, Helgoland. Connemara, Liverpool Bay, Pas de Calais, Messina, South America (cp. Hartlaub, 53; Broch, 50; Thornely, 63).

CAMPANULINIDAE.

Opercularella lacerata (Johnston).

At Positions 4, 10, 11, 13, 14, 32, 40, 62, 64, vii.

Depth, 40–49 fath. or over.

On Hydroids and *Cellaria*. The species is probably of commoner occurrence over the area than these records show. Growth in most cases simple, with single polyps arising from a stolon. Branching specimens occurred at Positions 13, 14, and 32. One specimen with gonangium at Position 32.

LAFÖEIDAE.

Laföea dumosa (Fleming).

In varying-sized colonies, creeping or branched, at nearly every position, including the last, 80.

Depth, 40–52 fath.

Laföea fruticosa, M. Sars.

At Positions 1, 11, 12, 31, 32, 36, 45, 49, 58, 60, 62; occurring mostly in very small colonies.

Depth, 40–50 fath.

Calycella fastigiata (Alder).

Only observed at Positions 36 and 40, on *Porella* and *Cellaria*.

Depth, 43–44 fath.

Cuspidella costata, Hincks.

At Positions 3, 49, 59, vii; growing on *Cellaria*.

Depth, 40–49 fath. or over.

HALECIIDAE.

Halecium beani (Johnston).

At Positions 4, 35, 38, 43. Very small colonies, excepting a large specimen at Position 35, on which gonangia were borne.

Depth, 40–45 fath.

Halecium halecinum (Linnaeus).

At Positions 1, 3, 10, 12, 33, 51, 53, 56.

Nowhere obtained in large quantities, and usually occurring as quite small colonies.

Depth, 40–49 fath.

Halecium muricatum (Ellis and Solander)?

At Positions 14 and 32.

Two small colonies in each case, growing on *Cellaria* and the dead stem of a *Sertularian* respectively. Height, from 8 to 27 mm. These specimens appear to belong to this species, but in the absence of any gonothecae their identity is left in doubt.

Depth, 42–44 fath.

Halecium labrosum, Alder.

At Position 12; one small colony of 20 mm. in height, growing on a tube of *Pallasia murata*.

Depth, 42 fath.

Halecium tenellum, Hincks.

At Positions 49, 59, 62, 80.

On *Antennularia*, *Cellaria*, etc. Plentiful at the two last-named positions.

Depth, 47–51 fath.

SERTULARIIDAE.

Sertularella gayi (Lamouroux).

At nearly all positions, including the last, 80.

Depth, 40–51 fath.

The species occurred rather plentifully on the fine sandy ground covered by the first cruise, i.e. within 10 miles of the Eddystone. On the rougher ground outside this, fair-sized colonies were found at Positions 60 and 80, some specimens at the latter point bearing gonangia. But in the great majority of the hauls the material obtained was small in quantity, and in many cases only very young colonies were observed.

Sertularella polyzonias (Linnaeus).

This species was only recorded from Positions 33, 49, and 62, in small colonies. It is not improbable that it was overlooked in some cases among the material of the preceding species.

Depth, 42–50 fath.

Sertularella tenella (Alder).

At Positions 11, 14, 31, 35, 42, 49, 53, 56, 67, 80.

Depth, 40–51 fath.

On *Sertularia abietina*, *Sertularella gayi*, *Diphasia attenuata*, *Hydrallmania*, etc., and on *Cellaria*; many colonies occurring at Positions 14, 35, and 56.

The species has not hitherto been recorded in the Plymouth fauna.

Distribution: Northumberland; South Devon; Filey, Yorks; Peterhead; Wick; Hebrides; Shetland (cp. Hincks, 55); Isle of Man (G. Wood, 64); Cuba; California; Rio de Janeiro (cp. Nutting, 60); Davis Strait; Smith Sound; Jones Sound; Jan Mayen; Spitzbergen; also in Sub-Antarctic Seas (cp. Broch, 50).

Diphasia attenuata (Hincks).

At Positions 14, 35, 49, 53, 56, 59, 60, 62, vii, 80.

Depth, 43–51 fath. or over.

Chiefly on *Cellaria;* occasionally on other Hydroids; at one position on a *Pallasia* tube. Several colonies at most of the positions enumerated. Especially well-grown colonies occurred at Position 62 with a few male gonangia, and at Position 80, with numerous female gonangia, respectively.

Diphasia pinaster (Ellis and Solander).

At Positions 1, 3, 6, 8, 10, 12, 13, 14, 51, 60, 80.

Depth, 40–51 fath.

A large colony occurred at Position 8. In other cases the specimens were of rather small size or quite young colonies.

Diphasia pinnata (Pallas).

One or two specimens at Positions 14, 35 (dead), 43 (fragment), 60, 62, vii, 80.

Depth, 43–51 fath. or over.

Female gonangia were borne on colonies from 14, 60, and 62.

Diphasia alata, Hincks.

Only obtained at Position 80, where a well-grown colony occurred.

Depth, 51 fath.

It is doubtful whether this species occurs in the Plymouth fauna. There is one specimen in the Laboratory without data, and a second—a good-sized colony, separated from its attachment—which was dredged up on the Mewstone Ledge in June, 1908. It is not certain that the latter specimen may not have found its way there through the medium of trawlers from outside, but in view of the fact that the natural habitat of the species is on the rough ground in the deeper water of the Channel, and far outside the ordinary trawling grounds, it seems more probable that the specimen grew where it was obtained. In the course of a cruise made by the *Oithona* in 1910, the species was found growing luxuriantly in the deeper water between the 50-fathom and 60-fathom lines—that is to say, immediately outside the limits of the cruises dealt with in the present report. Hincks (54) gives as localities of its occurrence: Shetland, and in 40 fathoms; Hebrides, Falmouth, Cornish coast. The distribution of the species outside British waters appears to be very limited: Stavanger, Norway, 50–100 fathoms (G. O. Sars, 62). *Hirondelle:* Bay of Biscay, 131–300 m.; Azores, 130–318 m. (Pictet et Bedot, 61). *Travailleur:* Bay of Biscay, 411 m. *Talisman:* Azores, 115 m. (Billard, 48).

Sertularia abietina, Linnaeus.

At Positions 9, 11, 14, 35, 43, 45, 49, 53, 59, 60, 62, 67, vii, 80.

Depth, 42–52 fath. or over.

On dead *Pecten* shells, etc. Few of the examples were in healthy condition, and several were dead and overgrown.

Sertularia argentea, Ellis and Solander.

At Positions 3, 7, 11, 12, 44, 49, 53, 56, 60, 80.

Depth, 40–51 fath.

On shells of *Pecten opercularis, P. maximus, Lutraria, Modiola,* etc. Mostly small or young colonies.

Hydrallmania falcata (Linnaeus).

This species was found generally distributed over the whole area, and was recorded at nearly all positions, including 62, 64, and 80. It was commonly attached to shells of *Pecten*, etc., and once *Porella*. It occurred very commonly on stones dredged up nearly everywhere, and in such cases often as good-sized colonies.

Depth, 40–51 fath.

Thuiaria articulata (Pallas).

A fragment only was obtained at Position 13.

Depth, 42 fath.

PLUMULARIIDAE.

Antennularia antennina (Linnaeus).

At Positions 1, 3, 4, 6, 7–12, 14, 15, 32, 38, 40, 43, 48, 49, 56, 58, 62, 64, vii, 77, 80.

Depth, 40–51 fath. or over.

Colonies occurred growing on shells and stones at Positions 7 and 62, several being so attached at the latter point. Specimens bore gonophores at 62 and at the doubtful position in Cruise VII. A fine colony was obtained at Position 64, but the growth was not otherwise remarkably luxuriant in specimens anywhere, and the quantity obtained was in most cases small.

Antennularia ramosa (Lamouroux).

At Positions 1, 3, 7, 13, 14, 32 (dead), 43, 60.

Depth, 40–50 fath.

A colony at Position 1 carried several *Scalpellum.* The species was not numerous at any point.

Aglaophenia myriophyllum (Linnaeus).

At Positions 11 (four), 14 (one), 32 (one), 33 (two), 37 (one), 40 (one), 43 (two small), 46 (one), 56 (one), 60 (two), 62 (four), 67 (one).

Depth, 40–50 fath.

Gonangia were borne on one colony at Position 60.

Aglaophenia tubulifera (Hincks).

At Position 60; several colonies on *Diphasia pinnata,* one with gonangia.

Depth, 49 fath.

Plumularia catharina, Johnston.

At Positions 1, 3, 4, 31, 33, 37, 38, 43, 52, 56, 59, 60, 62, vii, 80.

Depth, 40–51 fath. or over.

Generally of small or very small size; on tubes of *Chaetopterus* and *Pallasia,* and on *Scalpellum, Macropodia, Hyas, Pecten, Cellaria,* etc.; often numerous, several colonies occurring at the same position; plentiful at Position 80. The creeping form described by Hincks (54) occurred exclusively at Positions 4, 37, 38, 52, 56, 59, 60; bearing gonangia at 37, 38, 52; and predominated over the branching form at 62 and 80. The branching form bore gonangia at Position 3.

Plumularia echinulata, Lamarck.

Small colonies at Positions 10, 31, 34.

Depth, 40–42 fath.

On a tube of *Pallasia,* on *Pecten opercularis,* and on *Porella,* respectively. I have been unable to distinguish these specimens from Hincks' description of *echinulata,* despite the fact that he only records it from shallow water, and that it has only hitherto been recorded at Plymouth inside the breakwater, and in the Yealm Estuary.

Plumularia frutescens (Ellis and Solander).

A fragment at Position 52, on *Macropodia.*

Depth, 43 fath.

Plumularia similis, Hincks.

A small colony at Position 56; several on *Sertularia abietina* at 60; and on *Macropodia* at 64.

Depth, 49–50 fath.

Plumularia pinnata.

At Positions 1, 3, 4, 7, 35, 43, 44, 45, 49, 51, 64, vii.

Depth, 40–53 fath.

On *Diphasia, Macropodia, Pisa, Cellaria*, etc. Gonangia were borne on colonies from Positions 3 and 4.

Plumularia setacea (Ellis).

At Positions 3, 36, 62, vii.

Depth, 40–50 fath. or over.

Colonies from all four positions bore gonophores.

At Position 62, and the doubtful position in Cruise VII, several colonies were obtained, growing on the creeping form of *Plumularia catharina,* and all of very slender growth and small size. In the largest group, at vii, not exceeding 15 mm. in height, two of the colonies bore numerous gonangia, and the greater number of the pinnae were monothecate. At 62 another group of four colonies occurred, of very minute size, not exceeding 3 mm. in height, and with all the pinnae monothecate. One of these bore a single gonangium. Nutting (59) refers to a minute form obtained by the *Albatross* from floating drift weed, which may be comparable with this. He treats it as an aberrant form of *setacea*, but suspects that the gonosome if present would prove it to be a distinct species. In regard to the specimens here considered, there can be no doubt that they all belong to *setacea*, while the entirely monothecate form at 62 is connected with the ordinary type by the intermediate, partly monothecate, form at vii.

Polyplumaria flabellata, Sars.

One small colony of 20 mm. in height was obtained at Position 56, and one large well-grown colony at Position 80.

Depth, 49–51 fath.

The species has not previously been recorded from British waters.

Distribution: Stavanger, Norway, 50–100 fath. (Sars, 62); Bay of Biscay, 134–300 m., and Azores, 130–318 m. (*Hirondelle*, Pictet et Bedot, 61); Bay of Biscay, 411 m., and Azores, 128 m. (*Travailleur et Talisman*, Billard, 48). Pictet and Bedot (48) regard the *Diplopteron insigne* of Allman (45), obtained off the south-west coast of Spain in 364 fath., and the *Polyplumaria pumila* of the same author (46), obtained by the *Challenger* at the Azores in 450 fath., as synonymous with *P. flabellata*.

Several fine colonies of this species were obtained during a cruise of the *Oithona* in 1910, from the deeper water between the 50–fathom and 60–fathom lines, in company with the colonies of *Diphasia alata* already alluded to under that species.

ALCYONARIA.

ALCYONIDAE.

Alcyonium digitatum, Linnaeus.

Recorded from three-fourths of the positions, including bottom samples; generally plentiful, and at 3, 53, and 68 abundant. The outermost point at which it was recorded was Position 66, distant 41 m., depth 52 fath., where it was plentiful. Of the seven hauls made outside this, three were bottom samples.

A single specimen of the yellow variety was obtained in 40 fath. at Position 4 (cp. Hickson, 53, p. 349).

ZOANTHARIA.

CORALLIMORPHIDAE.

Corynactis viridis, Allman.

Several specimens of this species were obtained on stones and on shells of *Pinna* at Position 80, but it occurred at no other position. Depth, 51 fath.

SAGARTIDAE.

Sagartia miniata (Gosse).

Chitonactis coronata (Gosse).

Paraphellia expansa (Haddon).

The records of these three species are incomplete. I am indebted to Mr. C. L. Walton for having pointed out to me the identity of some of the specimens which he examined in life, admitting of the general statement that *Sagartia miniata* occurred at about fifteen positions, extending over the whole area investigated, while the occurrence of *Chitonactis coronata* and *Paraphellia expansa* was limited to comparatively few positions, though hardly less limited in extent.

Adamsia palliata (Bohadsch).

At Positions 6, 8, 11, 13, 35, 43, 46, 49, 59.

Depth, 42–49 fath.

In most cases as single specimens, and always with the species *Eupagurus prideauxi* when a Pagurid was present (see p. 355).

It is remarkable that though *Eupagurus bernhardus* was frequently recorded, its common associate *Adamsia polypus* never occurred (see p. 299).

ZOANTHIDAE.

Epizoanthus incrustatus, Düben and Koren.

Two specimens were obtained at Position 43, of the carcinoecious form, with six and seven polyps respectively.

Depth, 45 fath.

Epizoanthus couchi, Johnston ?

At Position 15, in 44 fath., two colonies apparently of this species occurred, each growing on a stone. In each case the polyps, which number seven and about fifteen respectively, are partly connected by a ribbon-shaped band, and partly isolated. All are strongly contracted, with the height not exceeding the diameter, which ranges from 5 mm. in the largest to 2 mm. in some of the young polyps. They are thickly incrusted with sand.

Epizoanthus sp.

At Positions 7 (one) and 42 (one), in 42–44 fath., a free form of *Epizoanthus* was obtained which rather closely resembles Holdsworth's description of *Zoanthus rubricornis* (57), and may belong to that species, but the colour of the tentacles was not observed in life. The first specimen consists of two polyps arising at an acute angle from a common base, the largest being 15 mm. in height by 4 mm. in diameter at apex. In the second specimen two polyps arise from a common base at an obtuse angle, their height and greatest diameter being 20 mm. by 5 mm., and 9 mm. by 4 mm. respectively.

TURBINOLIDAE.

Caryophyllia smithi, Stokes.

Recorded at Positions 7, 8, 9–13, 15, 18, 19, 33, 35, 37, 43–45, 47, 53, 56, 58, 59, 62, 64, 80.

Depth, 42–53 fath.

More than one and often several specimens occurred at each position, on shells and stones; many specimens at Position 80. The barnacle *Pyrgoma anglicum* was associated with individuals at 7 (one), 11 (one), 45 (two), and 59 (one).

ECHINODERMATA.

ASTEROIDEA.

ASTROPECTINIDAE.

Astropecten irregularis (Pennant).

A few specimens at Position 4, and single specimens at Positions 37, 49, 59, and 68.

Depth, 40–52 fath.

Luidia sarsi, Düben and Koren.

Single specimens at Positions 34 and 68.

Depth, 42–52 fath.

Luidia ciliaris (Philippi).

At Positions 7 (a few), 10, 18, 26, 28, 34, 35, 40, 43, 46 (juv.), 52, 62 and 64 (one each), 68 (five), 72 (one), 78 (two).

Depth, 42–53 fath.

In his Report on the fauna between the Eddystone Grounds and Start Point, Dr. Allen (1) records three specimens of the preceding species but no occurrence of *L. ciliaris*, and refers to the statement of Ludwig that *L. ciliaris* is generally taken on hard ground, while *sarsi* prefers a muddy or sandy ground. The comparative frequency of *ciliaris* and scarcity of *sarsi* in the area at present under consideration may perhaps be chiefly attributed to the frequently rough character of the ground in this region being more favourable to the former species than to the latter. Ludwig's expression (73, p. 81) . . . "sandigen Boden, namentlich solchen, der mit kleinen Steinen, Conchylien, Corallineen und allerlei Detritus untermischt ist" nearly describes the general character of this area, or at least the smoother parts of it.

Distribution: Sicily, Gulf of Naples, Nice, Gulf of Marseilles, Gulf of La Ciotat, Banyuls, Minorca, Cape Verde Is., Arcachon, Concarneau, Roscoff, Plymouth, Polperro, Falmouth, Stackpole Head, Isle of Man and Irish Sea, S.W. Coast of Ireland, in 55 fath., Kenmare R., Arran,* Berwick Bay, Shetland Is., Scarborough, Faeroe Is., Jutland (?),† Skager Rak (cp. Ludwig, 73; Bell, 65; Forbes, 66).

Vertical Distribution, 4–159 m. (cp. Ludwig, 73).

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* In quoting this record, which is apparently the same as that of Forbes, Bell does not refer to the fact that Forbes does not in this case make it clear to which "variety," as he terms it, the record applies, i.e. whether to *ciliaris* or *sarsi*, but it may be that Bell had definite data to refer to.

† Ludwig questions the certainty of this record (73, p. 81).

GYMNASTERIIDAE.

Porania pulvillus (O. F. Müller).

At Positions 7 (one ?), 8 (two), 20 (one), 34 (three), 36, 37, 59 (one); 64 (one).

Depth, 42–53 fath.

ASTERINIDAE.

Palmipes placenta (Pennant).

At Positions 1 (one), 3 (one), 34 (one small), 37 (one small), 70 (a few).

Depth, 40–43 fath.

SOLASTERIDAE.

Solaster papposus (Fabricius).

At Positions 7 (a few), 8 (a few), 15 (one small), 20 (one), 31 (a few), 34 (one small), 43 (one young), 49, 62, 66 (one), 67 (one), 68 (two).

Depth, 42–52 fath.

ECHINASTERIDAE.

Henricia sanguinolenta (O. F. Müller).

At Positions 8 (four), 25, 44 (one), 45 (one), 59 (two), 77 (one).

Depth, 43–49 fath.

ASTERIIDAE.

Asterias glacialis, Linnaeus.

At Positions 3 (several), 7, 8 (a few), 11 (one), 12 (one), 28 (a few), 34 (one), 35 (two very large), 37 (one), 49 (one), 56, 64 (one), 68, 70 (one).

Most of the records, excepting that at 35, are entered as "large" specimens.

Depth, 40–53 fath.

Asterias rubens, Linnaeus.

At Positions 3 (several), 7, 8 (about a dozen), 22 (one), 31, 32 (two), 34 (two), 35 (three), 36 (one), 37 (four), 49 (one), 51 (one), 53 (one young, diam. 35 mm). 59 (one small), 64 (one), 66 (one), 68 (two), 70 (three), 72 (three), 78 (two).

Mostly entered as "large" specimens.

Depth, 40–53 fath.

OPHIUROIDEA.

OPHIOLEPIDAE.

Ophiura ciliaris (Linnaeus).

At Positions 1, 3, 7, 10, 11, 14, 31, 34, 37, 56, 58, 68, 72.

Single or few specimens at each position. Perhaps 35 specimens in all.

Depth, 40–52 fath.

Ophiura albida, Forbes.

At Positions 1, 2, 11, 12, 15, 31, 32, 37, 43, 44, 47, 53, 55, 56, 63.

A few specimens, or more often single specimens, at each position, excepting several—about ten—at 43.

Depth, 40–50 fath.

Ophiura affinis, Lütken.*

At Positions 5 (four), 46 (one).

Depth, 42–47 fath.

A single specimen of this species obtained by Dr. Allen on the Bolt Head shell gravel ground in 1895 (1, p. 470) is the only previous record of its occurrence in the English Channel.

Distribution: Seaham (Hodge, 68), Firth of Clyde, Shetland (very abundant near Balta), Northumberland coast (Norman, 78, 79; Hodge, 69), Peterhead, Bass Rock, Dogger Bank, Skager Rak (Möbius and Bütschli, 77), Christiania Fjord, The Sound (Lütken, 74), S.W. of Ireland (Haddon, 7), Lesina, Ragusa (Heller, 67), S.E. of Long Island (?) (Leyman, 76).

Vertical Distribution, 6–294 fath.

AMPHIURIDAE.

Ophiactis balli (Thompson).

Recorded from 33 positions in the following proportions:—

From one to five specimens at Positions 1, 5, 7, 40, 47, 53.

A few or several specimens at Positions 6, 8, 10, 11, 12, 16, 18, 32, 33, 34, 43, 44, 45, 56, 59, 62, 80.

Many, or common at Positions 3, 14, 38, 49, 55.

Very common or abundant at Positions 9, 13, 15, 70.

Depth, 40–51 fath.

While these terms serve as a rough approximation to the proportionate distribution of the species, it must be added that they probably in many cases tend to show an under-estimate of actual numbers, and with the exception of the fine sandy ground covered by the hauls 1–4, it might be nearly correct to describe the species as usually very common and often abundant throughout the whole area.

OPHIOCOMIDAE.

Ophiocoma nigra (O. F. Müller).

Recorded from 41 positions, including the first and the last.

Depth, 40–52 fath.

The species was nowhere obtained in large numbers. Many specimens, perhaps twenty or twenty-five, occurred at 31 and 53; about a dozen at 21, 22, 30, 34–36, 44–46, 52, 56; few specimens or single specimens at all other positions, including 1 and 80.

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* Mr. W. De Morgan kindly determined this species.

OPHIOTHRICIDAE.

Ophiothrix fragilis (O. F. Müller).

Recorded from 23 positions, including the first and 63 and 64, but not 80.

Depth, 40–53 fath.

Nowhere obtained in large numbers. The greatest number, not exceeding about a dozen, occurred at Positions 5, 59, and 70. At the other points only a few or single specimens occurred. Small or young specimens were recorded at ten positions, viz. 1, 4, 5, 9, 10, 33, 40, 46, 53, 63.

The frequent occurrence of these small specimens is remarkable, while no such entry occurs in the records of the preceding species. In point of numbers and frequency of occurrence it seems evident, from whatever cause, that *Ophiocoma nigra* is by far the predominating species on these outer grounds. Reducing the comparative terms of entry used for the several records to rough numerical estimates where figures are not shown, I calculate that the total numbers recorded of the two species, *O. fragilis* and *O. nigra* respectively stand in the proportion of about 1 : 2·75.

ECHINOIDEA.

ECHINIDAE.

Echinus acutus, Lamarck.

At Positions 7, 31, 35, 36, 43, 49, 52, 72.

Depth, 40–47 fath.

These positions all lie between fifteen and thirty-one miles from the Eddystone, at a depth of 40–43 fath. Very few specimens of the species occurred, not more than three being recorded from any position.

Echinus esculentus, Linnaeus.

In marked contrast with the preceding, the extent of occurrence of this species will best be shown by giving the records, as far as they were made, in actual figures. Where numbers are omitted after a position the number of specimens was not recorded, but may be regarded as one or few.

At Position 1 (one), 3 (few), 7, 8, 12 (one), 20 (few), 22 (one), 32 (one), 34 (seven), 36 (one), 43 (two), 45 (four), 46 (nine), 49 (twenty, and two young), 51 (one)' 52 (five), 53 (three), 56 (one) 58 (one young), 59 (one young), 66 (thirteen), 67 (two), 68 (eight), 70 (few), 72 (few), 78 (eleven), 80.

Depth, 40–52 fath.

The total number recorded is about 120, as opposed to about 15 of the preceding species. In his Report on the fauna between the Eddystone Grounds and Start Point, Dr. Allen (1) discusses in detail the conditions influencing the distribution of these two species. In regard to the great numerical difference between them in the area now dealt with, it is probable that Dr. Allen's remarks on the bare survival of *acutus* in the Plymouth area as being on the outskirts of the deep-water area, where it abounds, are directly applicable to the present case, since the deepest positions now under consideration extend very little beyond the 50-fathom sounding. It is this line that apparently marks the inner limits of the conditions especially favourable to the species, and its non-occurrence in the few hauls that were made near that depth may be due to local conditions.

In a recently published number of this Journal, Shearer, De Morgan, and Fuchs* express a difficulty in distinguishing many specimens of *acutus* and *esculentus* from one another, and even a doubt as to their true specific distinction. As regards specimens here recorded, no such confusion between the two forms as separated was noticeable, though in most cases where *acutus* was found the two species occurred together.

Echinus miliaris, Linnaeus.

A single specimen was obtained at each of the positions 1 and 80.

Depth, 40–51 fath.

CLYPEASTRIDAE.

Echinocyamus pusillus (O. F. Müller).

At Positions 1 (several), 45 (a few), 56 (one).

Depth, 40–49 fath.

Spatangus purpureus, O. F. Müller.

Large specimens at Positions 5, 9, 10, 11, 74 (one each), and 67 (two).

Medium-sized specimens at Position 46 (a few).

Small or young specimens at Positions 5 (a few), 17 (one), 20 (one), 31 (a few), 36 (one), 46 (several), 51 (a few), 56 (one), 58 (several).

Depth, 40–49 fath.

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* "Preliminary Notice on the Experimental Hybridization of Echinoids," *Journ. Mar. Biol. Assoc.*, N.S., Vol. IX, 1911.

The large proportion of small specimens is remarkable.

The mollusc *Montacuta substriata* was attached to some of the specimens at Position 46, but it was not recorded in other cases.

SPATANGIDAE.

Echinocardium pennatifidum, Norman.

Five specimens on rough ground at Position 58.

Depth, 49 fath.

Length, 29, 34, 38, 39, 41 mm. respectively.

HOLOTHUROIDEA.

CUCUMARIIDAE.

Cucumaria brunnea, Thompson.

At Positions 3 (one), 4 (one), 43 (two).

Depth, 40–45 fath.

Cucumaria hyndmani, Thompson.

One specimen at Position 35.

Depth, 43 fath.

Thyone fusus (O. F. Müller).

One specimen at each of the Positions 11 and 33.

Depth, 42 fath.

Thyone raphanus, Düben and Koren.

One specimen at Position 14.

Depth, 44 fath.

Two examples of this species, which has not previously been recorded in the Plymouth fauna, were recently identified by Mr. J. H. Orton from three miles south of Rame Head, where they were obtained in July, 1911. Bell (65) gives as its distribution: British and Norwegian seas and Mediterranean; with the British localities: Faeroe Channel, 570 fath.; Shetland; The Minch; Dingle Bay, 40 fath., off the S.W. coast of Ireland. Also Irish Sea (Herdman, 9).

ANNELLIDA.

POLYCHAETA.

SYLLIDAE.

Typosyllis alternosetosa, de St. Joseph.

At Positions 14 (one), 33 (one), 38 (two), 43 (one), 45 (one), 52 (one), 56 (one), 58 (one), 59 (one).

Depth, 42–49 fath.

Typosyllis variegata, Grube.

At Positions 38 (two), 43 (one), 53 (one), 58 (one).

Depth, 44–49 fath.

The specimens appear only to differ from the account of Langerhans in the smaller number of articulations in the dorsal cirri of the body. Langerhans gives these as 34 and 24 in alternate segments. In these specimens they number about 24 and 16 respectively. Grube (83) first described the chaetae as with simply hooked end-pieces. Subsequent authors have described them as bifid. In all the specimens here considered they are very faintly bifid in some of the anterior segments, but distinctly so in the median and posterior segments. The transversely-placed 8-shaped dark marking, as described by Langerhans, in the dorsal surface of the segments, is distinct in the anterior segments of some specimens but absent in others (as preserved in spirit).

HESIONIDAE.

Castalia punctata (O. F. Müller).

One specimen at Position 33. Length in spirit, 10 mm.

Depth, 42 fath.

APHRODITIDAE.

Aphrodita aculeata, Linnaeus.

At Positions 6 (one), 11 (one), 31 (a few).

Depth, 40–42 fath.

Hermione hystrix (Savigny).

At Positions 8, 11, 16, 17 (one each), 18 (two), 19 (one), 20, 22, 25 (two), 31, 35 (one), 37 (one), 38, 43 (one), 44 (two), 58 (one), 59 (three), 62.

Depth, 43–50 fath.

The greater frequency of this species in comparison with the preceding is probably due to the generally rough character of the ground being more favourable to it (cp. Allen, 1).

Lepidonotus squamatus (Linnaeus).

At Positions 13 (one), 34 (one), 70 (two).

Depth, 40–42 fath.

Lagisca floccosa (Savigny).

At Positions 10, 12, 13, 14, 32, 33, 34, 35 (one each); 45 (three young), 49, 51 (two each), 58 (three), 59 (four), 60, 62 (two each), 70 (four), 72 (one), vii (two), 80 (seven).

Depth, 42–51 fath. or over.

Harmothöe setosissima (Savigny).

At Positions 46 (two), 52 (one), 53 (one), 56 (one).
Depth, 43–49 fath.

Harmothöe fraser-thomsoni, McIntosh.

One specimen at each of the Positions 56 and 80.
Depth, 49–51 fath.

Harmothöe lunulata (Della Chiaje).

One specimen at the doubtful position in Cruise VII.
Depth, 49 fath. or over.

Evarne impar (Johnston)?

One specimen at each of the Positions 10 and 32.
Depth, 40–42 fath.

The specimens only differ from the description and figures of McIntosh (91) for the species in the character of the ventral chaetae, in which the secondary process is very largely lacking. In one specimen this is absent from about the inferior third of the series. In the other it is only visible as a very fine process in about ten of the extreme superior chaetae. With the absence of this process is associated a corresponding diminution and even entire absence of the spinulation on the chaetae concerned. In the second specimen referred to, especially, many of the inferior chaetae are entirely bare in this respect. These remarks refer to about the tenth foot in each case. Both are young specimens, the largest not exceeding 10 mm. in length, and the nearer approximation of this latter to the type suggests that the difference may be due to immaturity.

Halosydna gelatinosa (M. Sars).

One specimen at Position 59.
Depth, 49 fath.

The specimen was broken into three pieces, but measured about 7 cm.

AMPHINOMIDAE.

Euphrosyne foliosa, Audouin and Edwards.

One specimen at Position 60.
Depth, 49 fath.

PHYLLODOCIDAE.

Phyllodoce rubiginosa, de St. Joseph.

One specimen at each of the Positions 45, 46, 58, and two at 59.
Depth, 46–49 fath.

NEREIDAE.

Nereis fucata, Savigny.

One specimen at each of the Positions 6 and 46, associated in each case with *Anapagurus laevis*.

Depth, 42–47 fath.

Nereis pelagica, Linnaeus.

One specimen at each of the Positions 7, 38, 46, 49, 58.

Length as measured in spirit, 35, 40, 40, 25, 20 mm., severally.

The specimen at 46 occurred in a *Pallasia* tube; the others were free.

Depth, 42–49 fath.

EUNICIDAE.

Eunice fasciata (Risso) = *E. harassii*, Audouin and Edwards.

One specimen at each of the Positions 4, 7, and 31.

Depth, 40–42 fath.

Eunice vittata (Della Chiaje).

One specimen at Position 32.

Length in spirit, 53 mm.

Depth, 42 fath.

Not apparently recorded from Plymouth since the time of Bate.

Distribution: Guernsey; *Porcupine* Expedition, Sta. xxvii, xxviii, xxviii*a*: Galway; Polperro; Plymouth: shores of France; Madeira; Mediterranean: Japan; Adventure Bank, *Porcupine*, 92 fath.; Cape Verde Is. (cp. McIntosh, 93).

Onuphis conchilega, M. Sars.

At Positions 6 (two), 13 (one), 16 (one), 32 (nine), 37 (one), 42.

Depth, 42-44 fath.

Hyalinoecia tubicola (Müller).

Recorded at 23 positions: 1, 5, 10–15, 17, 19, 22, 31, 35–37, 41, 42, 49, 51, 52, 56, 58, 67.

From one to about fifteen specimens at each point, the number averaging about four.

Depth, 40–52 fath.

Lumbriconereis fragilis, O. F. Müller ?

A single specimen at each of the Positions 46 and 58.

Depth, 47–49 fath.

A considerable portion at each extremity is lost in both examples.

The feet and bristles agree with those described and figured by McIntosh for this species.

Distribution: At various stations off the British shores, in 15–1380 fath. (*Porcupine*); W. and S.W. coast of Ireland, in 30–50 fath.; Connemara; Nova Zembla; Siberia and Behring Strait; Canada; (cp. McIntosh, 93).

SPHAERODORIDAE.

Ephesia gracilis, Rathke.

Single specimens at Positions 11, 15, 32, 33, 38, 49; and apparently occurring at other points not definitely recorded.

Depth for recorded specimens, 42–47 fath.

CHAETOPTERIDAE.

Chaetopterus variopedatus, Renier.

Living specimens were obtained at Positions 3, 4, 7, 9, 10, 12, 13, 43, 58, 59, 68, 70, 80; single specimens or a few only, in each case; in tubes of *Pallasia*, in a shell of *Buccinum*, winding through the whorls of *Fusus islandicus*, etc. Empty tubes only were recorded at Positions 1, 2, and 55.

Depth, 40–51 fath.

TEREBELLIDAE.

Polymnia nebulosa (Montagu).

At Positions 11, 31, 40, 45 (one each), 58 (two), 59 (three), 64 (one), vii (five).

Depth, 40–50 fath. or over.

Large specimens occurred at 59, and vii, attaining to 12 or 13 cm. in length.

Polymnia nesidensis (Della Chiaje).

One specimen at Position 60.

Depth, 49 fath.

Lanice conchilega (Pallas).

Empty tubes only of this species were obtained at Positions 10, 11, 32, 35, 60.

Nicolea venustula (Montagu)?, de St. Joseph.

At Positions 11 (one), 12 (two), 43 (two), 59 (three), 60 (two), 62 (one), 72 (one).

Depth, 42–50 fath.

The specimens range from 2 to 5 cm. in length. All have two pairs of gills, and so far as can be ascertained 17 setigerous segments. The only doubt as to the latter point concerns a few specimens that were partly broken, and in which the number of segments is not quite clear. The species is undoubtedly the *Nicolea venustula* of Marenzeller (96) and de St. Joseph (101). But whatever may be said of the justification for Marenzeller's reference of this type to the *Terebella venustula* of Montagu, with 3 pairs of gills, the evidence he quotes in favour of his conclusion that the *Nicolea zostericola* of Oersted, sec. Grube et Malmgren, is synonymous with *venustula* seems far from convincing, and his view is not shared by de St. Joseph. Neither Marenzeller nor de St. Joseph finds any departure in the examples of *venustula* personally recorded by them respectively, from the typical condition of 2 pairs of gills and 17 setigerous segments. Such also is the condition, probably without exception, of the specimens recorded here. It is significant that in Plymouth both types occur distinctly. Dr. Allen has found *zostericola* common within tide-marks in Plymouth Sound. Among 14 examples of his material recently examined, I have found the number of setigerous segments invariably 15, excepting in one specimen which was slightly damaged and in which, probably in consequence, only 14 were distinct. All of these are of small size, not exceeding (in spirit) 2 cm. in length. On the other hand, seven specimens of *venustula* obtained by him from a position 32 miles S. of Start Point, in about 40 fathoms, have, without exception, 17 setigerous segments. Some of these range as low as 2 cm. in length, so that the difference in the number of such segments between the two types would seem to be independent of size or age.

These facts, and the occurrence of the two types near Plymouth under different respective conditions, and apparently without variation in the characters mentioned, favour the view that they are specifically distinct. In Plymouth at least, *zostericola* appears to be essentially a littoral form of comparatively slender habit and small size, while *venustula* frequents the deeper water and assumes a stouter form and larger size. The number of setigerous segments moreover, 15 in *zostericola* and 17 in *venustula*, may apparently be regarded as a sufficiently stable character on which to separate the two species from one another.

Thelepus cincinnatus, Fabricius.

At Positions 1, 3 (a few), 14 (one), 32 (one), 33 (two), 34, 35, 43 (one each), 45 (three), 49 (one), 51 (two), 56, 60 (three each), 64 (one), 70 (two).

Depth, 40–50 fath.

In referring the examples recorded to the species *cincinnatus* more importance has been attached to the character of the gills, which are present without exception on two segments only, than to the uncini, which are very variable in form. The specimens range from young examples of about 12 mm. in length to large ones of 10 cm. Between such extremes the only noticeable difference in the uncini is one of size. The irregularity of form occurs in both, though the range of variation seems greater in the larger specimens. The uncini conform on the broad lines with the description and figure of de St. Joseph (103), but often differ much in detail.

Regarding the uncinus from the face and tracing it from below upwards, there is first (a) the large central tooth, or "great fang," so termed by McIntosh. Above this (b) are usually two, but very often three, strong teeth, of which the central one, when present, has a slightly higher origin than the laterals. Next follows (c) a range with two small lateral teeth and one larger central one. This central tooth is the homologue of the large central tooth in the (b) range, and when present in the latter it is therefore absent from the range above in the reckoning adopted, and the (c) range then has the two small laterals only. Finally (d) occurs a range of very small teeth, about three to five in number, which fill in the apical space. These occasionally extend around the apical margin of the uncinus, so that their two extreme laterals lie one on either side of the (c) range, and the latter then appears to possess altogether five teeth, or four as the case may be. In a preparation of a young specimen of 18 mm. in length, the condition with three teeth in the (c) range is the most frequent, while apically the arrangement is much confused, and the remaining teeth are crowded together with little appearance of order. It must be added that the use of the term "range" is quite artificial, all of the teeth lying closely apposed, so that any irregularity occurring is liable to confuse the scheme of arrangement considerably.

In the profile view a difference occurs from the figure by Malmgren (94), which shows the uncinus rather narrower in antero-posterior measurement, and with the apex simply rounded and without the slight projection where the extreme apical teeth are borne. Malmgren's figures are as a rule so true to life that this difference presents some difficulty. The second point, however, is involved in Marenzeller's figure of the species (96), where the apical projection is distinctly shown. From the description of the species by Marenzeller and de St. Joseph the only important discrepancy is the frequent enlargement of the central tooth in the (c) range and its extension as a third tooth into the range immediately below. This character, which is not mentioned by either of these authors, occurs, I believe, in every preparation of the species I have seen, including some specimens collected by the *Huxley* in the North Sea.

AMPHICTENIDAE.

Pectinaria (Petta) pusilla, Malmgren.

One specimen at each of the Positions 33 and 34. Length (in spirit), 13 and 15 mm. respectively. The second example was associated with an Ascidian inside a valve of *Pecten opercularis.*

Depth, 42 fath.

The specimens only differ from Malmgren's description (94) in the point of the membranous fold under the paleolae. This is triangular, as in *P. assimilis*, McIntosh (90). The shape of this, however, is not clearly defined by Malmgren, who figures it slightly emarginate in the dorsal view, and overhanging in the ventro-lateral view of the whole animal. It is conceivable that in the single specimen he had before him the natural outline of the process was indistinct. In all other respects the examples are in close conformity with Malmgren's account of the species. Since the occurrence of Malmgren's specimen, which was obtained by Loven off the coast of Bohus in the Skager Rak, the species seems only to have been recorded from the Firth of Clyde (cp. Gemmill, 82).

SABELLIDAE.

Sabella pavonina (Savigny).

Usually small specimens at Positions 1, 7, 8, 31, 34, 35, 37, 40, 53, 59, 80.

Depth, 40–51 fath.

Dasychone bombyx (Dalyell).

At Positions 1 (several), 3 (one), 55 (a few), 59 (one), 60 (one), 70 (three), 72 (one), vii (one).

Depth, 40–49 fath. or over.

SERPULIDAE.

Serpula vermicularis, Linnaeus.

At Positions 7 (a few), 8 (several), 9 (very common), 13 (two), 14 (a few), 32, 43 (one), 49 (several large), 59 (one), 60 (two), 72 (one).

Depth, 42–49 fath.

Commonly attached to stones and shells of *Pecten.* The records are probably incomplete.

Pomatoceros triqueter (Linnaeus).

At Positions 6, 7, 80, and probably in several other hauls.

Depth, 42–51 fath.

Hydroides norvegica (Gunn).

Recorded at Positions 4, 6, 11, 13, 32, 58. About 50 examples on a valve of *Pecten opercularis,* at Position 13.

Depth, 40–49 fath.

Ditrupa arietina (O. F. Müller).

One specimen at Position 36.

Depth, 43 fath.

The species does not appear to have been previously recorded from the English Channel.

Distribution: Gulf of Naples, Teneriffe, Madeira, Azores, Bay of Biscay, S.W. of Belle Isle, N.W. coast of Ireland, W. coast of Scotland, Shetland, Norway, Philippine Is.—cp. Lo Bianco (88), Langerhans (87), McIntosh (89, 90), Roule (98), de St. Joseph (103), Johnston (85), Sars (105), Grube (84).

Filograna implexa (Berkeley) ?

At Positions 7, 8, 37.

Depth, 42–43 fath.

De St. Joseph (101) distinguishes *Filograna implexa,* as with opercula, from *Salmacina dysteri* as without them. Cunningham and Ramage * treat the two as synonymous, a view which is shared by Prof. McIntosh. The specimens which were recorded in the preliminary list as *Filograna implexa* were unfortunately not retained for examination of this character, and the species is therefore left in doubt.

Protula tubularia (Montagu).

Single specimens at each of the Positions 9, 33, 59, vii.

Depth, 42–49 fath. or over.

Spirorbis spirillum (Linnaeus) ?

A small *Spirorbis,* apparently of this species, occurred commonly on Hydroids, especially on *Sertularia abietina,* at many points, and was definitely recorded at Positions 11, 14, 35, 42, 43, 53, 60, 62, 67, 80.

Depth, 42–51 fath.

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* "The Polychaeta Sedentaria of the Firth of Forth," *Trans. Roy. Soc. Edinburgh,* Vol. XXXII, p. 635.

HERMELLIDAE.

Sabellaria spinulosa, Leuckart.

Recorded in small numbers at Positions 4–7, 13, 31–33, 35, 44, 45, 47, 49, 51, 53, 56, 59, 60, 72, vii, 80.

Most commonly on shells of *Pecten*, also on tubes of *Pallasia* and on stones.

Depth, 40–51 fath. or over.

Pallasia murata, Allen.

Tubes or portions of tubes of this species were obtained at Positions 5, 6, 7, 10, 11, 12, 14, 17, 19, 31, 32, 37, 46, 53, 56, 63, 72.

Depth, 40–50 fath.

Living specimens or fragments of such were obtained at Positions 17, 63, and 72. A large colony was passed through at Position 17, where portions of about six specimens of the living animal were brought up in the dredge. This was by far the largest settlement touched in the course of the work (cp. Crawshay, 4, p. 103), though the absence of living specimens in the great majority of the hauls is largely to be explained by the difficulty of working the dredge deep enough to secure them.

HIRUDINEA.

Pontobdella muricata, Linnaeus.

One specimen at each of the Positions 44 and 52.

Depth, 43–46 fath.

At Position 44, in addition to the specimen, four lots of ova were obtained in dead valves of *Pecten opercularis.*

SIPUNCULOIDEA.

Phascolosoma vulgare (de Blainville).

One specimen at each of the Positions 15 and 38. Length 30 and 20 mm. respectively.

Depth, 44 fath.

Mr. G. Southern kindly identified this species.

ARTHROPODA.

CRUSTACEA.

CIRRIPEDIA.

BALANIDAE.

Balanus crenatus, Bruguière.

Recorded only at Position 4, but probably present in other hauls.

Pyrgoma anglicum, Leach.

On *Caryophyllia smithi*, at Positions 7, 11, 44, 45, 59.

Depth, 42–49 fath.

VERRUCIDAE.

Verruca stroemia (O. F. Müller).

Recorded at Positions 4, 35, and 72, on shells of *Pecten opercularis* and *Fusus islandicus.* Probably present in other hauls.

Depth, 40–43 fath.

LEPADIDAE.

Scalpellum vulgare, Leach.

Generally in small numbers, at Positions 1, 3, 5, 9, 11–14, 17, 19, 31, 32, 33, 35, 37, 38, 40, 42, 43, 46, 49, 59, 60, 62, 64, 67, 70, 77, 80. On *Antennularia antennina*, *A. ramosa*, *Aglaophenia myriophyllum*, *Halecium halecinum*, and other Hydroids; and at Position 64, about 50 specimens on tube of *Lanice conchilega.*

Depth, 40–51 fath.

PELTOGASTRIDAE.

Sacculina carcini, Thompson.

One specimen at each of the Positions 14 (on *Pisa biaculeata*), and 60 (on *Macropodia longirostris*).

Depth, 44–49 fath.

Peltogaster sulcatus, Lilljeborg.

Eight individuals of this rare species were obtained at Position 59, parasitic on a specimen of *Eupagurus cuanensis.*

Depth, 49 fath.

Geoffrey Smith (135, p. 108) recognizes, among the various names given to the genus, only two certain species, *P. paguri* and *P. sulcatus.* Under the synonyms of the latter he records, as the hosts and distribution of the species: *Pagurus cuanensis, chiracanthus* and *laevis,* from Danish and Norwegian Seas; *E. prideauxi* and *meticulosus,* from Naples; an unnamed host from French coasts; *Pagurus sp.* ? from Brazil; and *Ligella gracilis* and *affinis* from Valparaiso.

The species is recorded by Norman (130, p. 226) "on examples of *Pagurus cuanensis* dredged in Teignmouth Bay." It was earlier recorded by him (127, p. 185), as "gregariously parasitic on *Pagurus laevis,* off Sunderland. New to Britain."

AMPHIPODA.

AMPELISCIDAE.

Ampelisca spinipes, Boeck.

One specimen at Position 1.

Depth, 40 fath.

LEUCOTHÖIDAE.

Leucothöe spinicarpa (Abildgaard).

At Positions 3 (four), 4 (two), 8 (two), 40 (one), 43 (one), 51 (one young).

Depth, 40–45 fath.

PARAMPHITHÖIDAE.

Epimeria cornigera (Fabricius).

At Positions 45 (four), 46 (one), 52 (one).

Depth, 43–47 fath.

Distribution: W. coast of Norway, Shetland and many localities off the British Isles, Bay of Biscay, Naples (cp. Chevreux, 112). Many examples obtained by the *Huxley* in the Bay of Biscay in 1906 have recently been recorded by Mrs. Sexton (134). Though recorded from Falmouth and South Devon by Leach and Montagu, the species has not been observed in the Plymouth fauna of late years.

IPHIMEDIIDAE.

Iphimedia obesa, Rathke.

One specimen at Position 1.

Depth, 40 fath.

PHOTIDAE.

Gammaropsis erythrophthalma (Lilljeborg).

Three specimens at Position 45.

Depth, 47 fath.

JASSIDAE.

Jassa pusilla, G. O. Sars.

At Positions 4 (two ovigerous females), and 5 (eleven examples). On a sponge coating *Inachus dorsettensis.*

Depth, 40–42 fath.

Mrs. Sexton kindly examined these specimens, and separated those from the latter position as follows:—

Full-grown,	3 males;	1 ovigerous female.
Young	2 „ ;	5 „ females.

For details concerning these specimens, see her account of the species (134, p. 216).

Distribution: South and west coasts of Norway, Hammerfest, Cumbrae (?), Firth of Forth, Port Erin, Eddystone, south-west of Belle Isle, Bay of Biscay (cp. Sexton, 134).

COROPHIIDAE.

Erichthonius abditus (Templeton).

Three specimens at Position 45.
Depth, 47 fath.

CAPRELLIDAE.

Phytisca marina, Slabber.

One male at Position 3.
Depth, 40 fath.

Protella phasma (Montagu).

At Position 3, two females, one with young in pouch.
„ 6, three males; five females, some with young.
„ 56, twelve immature specimens. Length, 3–5½ mm.
Depth, 40–49 fath.

ISOPODA.

ANTHURIDAE.

Anthura gracilis (Montagu).

One specimen at Position 7.
Depth, 42 fath.

A particular point of interest attached to this specimen is the fact that it was found deeply intruded, head downwards, in a tube of the Polychaet worm *Sabellaria spinulosa*, the only part visible being the ends of the uropoda lying nearly flush with the opening of the tube. With these peculiarly shaped organs lying in this position, their appearance was so deceptive to the eye that they might easily be mistaken at a rough glance for the anterior region of the original occupant of the tube. Whatever significance may be attached to this resemblance, the main fact goes to suggest that the animal was preying on the *Sabellaria*. This inference is supported by the view that the oral parts of the Anthuridae point to a parasitic habit, though the mode of parasitism has not hitherto been stated (cp. G. O. Sars, 132, p. 44). The peculiar shape of the animal and the unusual form of the uropoda would seem well adapted to association with any such host.

AEGIDAE.

Rocinela damnoniensis, Leach.

At Positions 1, 5, 10 (one each), 11 (two), vii (one).
Depth, 40–49 fath. or over.

CIROLANIDAE.

Conilera cylindracea (Montagu).

One specimen at Position 10.

Depth, 42 fath.

ARCTURIDAE.

Astacilla longicornis (Sowerby).

Two specimens at Position 1.

Depth, 40 fath.

DECAPODA.

MACRURA.

PANDALIDAE.

Pandalus brevirostris, Rathke.

At Positions 1 (four), 33 (one), 45 (six), 52 (three young).

Depth, 40–47 fath.

HIPPOLYTIDAE.

Hippolyte varians, Leach.

Four specimens at Position 45.

Depth, 47 fath.

ALPHEIDAE.

Alpheus macrocheles (Hailstone).

One at each of the Positions 58, 59, 62, 68.

Length of specimens, 21, 17, 23, 40 mm., the last being an ovigerous female.

Depth, 49–50 fath.

CRANGONIDAE.

Crangon allmanni, Kinahan.

One specimen at Position 60. Length, 38 mm.

Depth, 49 fath.

ANOMURA.

GALATHEIDAE.

Galathea dispersa, Spence Bate.

Recorded from positions as follows:—1 (two), 5 (one), 13 (one), 40 (two), 43 (three), 49 (two), 51 (one), 52 (three), 56 (two), 58 (one), 59 (two), 62 (three), vii (one).

Depth, 40–50 fath. or over.

The records of this species are probably incomplete.

Galathea nexa, Embleton.

At Positions 58 (six), and 59 (one).

Depth, 49 fath.

The tendency in recent years has been to combine this species with the preceding, but I have followed Bonnier (110) in retaining it as distinct. The peculiar *facies* of *G. nexa* is remarkable to the naked eye owing to the much stronger spination and hispidation of the first peraeopods especially, and also in the generally shorter form of these appendages than in *G. dispersa*. These distinctions cannot be sexual in character, for though in a different degree they occur in both sexes, and the chelae are more strongly spined in the females of *nexa* than in the males of *dispersa*, the difference being especially marked in the large spine on the carpopodite.

The chief character of distinction used by Bonnier, namely, the relative length of the ischiopodite and meropodite of the third maxillipede, seems to me of little value as compared with the character of the large spine in the ventral region of the meropodite of that appendage. This is centrally situated and isolated in *nexa* as figured by Bonnier (Pl. XII, Fig. 7), but more distally situated and as a rule accompanied by a second smaller though prominent spine nearly adjacent and distal to it in *dispersa*. Bonnier's figure of this joint in *dispersa* is very misleading, owing conceivably to its having been drawn in such a position as to throw out the perspective, creating the impression that the large spine has a distal position. Milne Edwards and Bouvier (124, p. 72) correct this, describing the position as "vers le milieu du bord inféro-interne," which accurately represents the position of the spine in the specimens now under consideration. It is chiefly owing to the same difficulty of Bonnier's figure that Hansen (114, p. 31) unites the species with *nexa*, and records his material under this as the prior name.

Another character of distinction which may prove of considerable value, is the nature of certain setae closely adjacent to the large spine in question. Bonnier makes no allusion to these setae, but figures them distinctly as faint pencil marks in his drawing of the third maxillipede of *G. nexa* (Pl. XII, Fig. 7). They are from two to four in number, and arise close to the origin of the large spine. In all the specimens of *nexa* I have examined, these setae are quite simple, while in those of *dispersa* they are clearly pinnate. The only exception occurs in a specimen of *dispersa* in which the largest of them is simple or nearly so, the others being pinnate. This character needs confirmation in a large number of examples, but the evidence points to its being a reliable mark of distinction. The point is remarkable in view of the fact that the condition is the reverse of that in the chelae. In the latter case it is the strongly pinnate setae—the "longs poils serrés" of Bonnier—covering the carpopodite and propodite, and forming the pronounced hispidation in *nexa*, that are contrasted with the comparatively scarce setae, only partially pinnate or quite simple, in *dispersa*.

Distribution: Lofoten Islands, and southern coasts of Norway; British Islands, from Shetland to Cornwall; Galoper, Luc-sur-mer, and Channel Islands (cp. Bonnier, 110). Kemp (117), in recording the species collected by the *Huxley* in the Bay of Biscay in 1906, follows Hansen and others in treating *dispersa* and *nexa* as synonymous, and on grounds of priority uses the latter name. He finds a closer resemblance, however, in the maxillipedes to the *dispersa* of Bonnier, and as a specimen of his material I have since examined is certainly of that species as here regarded, it is probable that the same applies to all of them.

Galathea intermedia, Lilljeborg.

One specimen at each of the Positions 1 and 43.

Depth, 40–45 fath.

Galathea squamifera, Leach.

Single specimens at Positions 10 and 33.

Depth, 42–43 fath.

PAGURIDAE.

Eupagurus bernhardus (Linnaeus).

Single or few specimens at Positions 1, 6, 7, 14, 20, 31, 32, 34, 36, 37, 42, 43, 52, 56, 59, 70.

In shells of *Buccinum undatum*, etc., and in the sponge *Ficulina ficus*. The records are unfortunately incomplete in detail, but few large specimens were obtained and there was no occurrence of the associated anemone *Adamsia polypus* (see p. 299).

Depth, 40–49 fath.

Eupagurus cuanensis (Thompson).

One or two specimens only at Positions 11, 12, 14, 16, 37, 52, 59, 60, 72.

In shells of *Fusus islandicus*, and once in *Murex erinaceus*, as far as recorded. A specimen occurred at Position 59, infected with the rare parasite *Peltogaster sulcatus* (see record of the latter species, p. 349).

Depth, 42–49 fath.

Eupagurus prideauxi (Leach).

Single or few specimens at Positions 1, 5, 6, 7, 9, 11, 13, 17, 20, 37, 43, 46, 49, 52, 53, 56, 59; and several at Position 60.

Depth, 40–49 fath.

The associated anemone, *Adamsia palliata*, was only definitely recorded in a few instances. It is most probable that this was an omission, due to the constancy of its occurrence with the species.

Eupagurus sculptimanus (Lucas).

From one to three specimens at Positions 10, 11, 12, 16, 19, 34, 36, 37, 40, 52, 80.

In shells of *Turritella*, *Dentalium*, etc.

Depth, 42–51 fath.

Anapagurus laevis (Thompson).

Single or few specimens at Positions 5, 6, 11, 46, 60, and probably present in other hauls.

Depth, 42–49 fath.

A single specimen was recorded with the commensal Polychaet, *Nereis fucata*, at Position 6.

Anapagurus hyndmanni (Thompson)?

Two specimens apparently belonging to this species were obtained at Position 59.

Depth, 49 fath.

The species has been recorded from Shetland, the Frith of Forth, the Firth of Clyde, Portaferry and Belfast Bay, Liverpool Bay, coasts of Devon and Cornwall, and Channel Islands, cp. Bell (109), Norman (11, 127, 128), Scott (133), Walker (136).

BRACHYURA.

PORCELLANIDAE.

Porcellana longicornis (Linnaeus).

Recorded at Positions 1, 3, 4, 9, 10, 11, 32, 53, 56, 58, 59, 63.

Depth, 40–50 fath.

LEUCOSIIDAE.

Ebalia cranchi, Leach.

At Positions 19 and 31. Apparently one specimen in each case.

Depth, 40–45 fath.

Ebalia tumefacta (Montagu).

One specimen at each of the Positions 19 and 63.

Depth, 45–50 fath.

The position of this species is far from satisfactory. The difficulty of its identification appears to me to consist in the separation of it, not from *E. tuberosa*, as found by Walker (136, p. 98), but from *E. cranchi*. *E. tuberosa* is readily distinguished from it, as from the latter, by the more elongate "hand" in the first peraeopods, and also especially by the much longer claws, both sexes showing these characters alike. These points are mentioned by Montagu (126, p. 86) in his original description of *Cancer tumefactus*, and figured by Leach and by Bell, while the last author even expresses his inability to account for the two species being confused with one another. Bell (109), as he interprets the species, describes the meropodite or "arm" of *E. tumefacta* (= *E. bryeri*) as not more than twice as long as broad, and that of *E. cranchi* as three times as long as broad, using this, moreover, as one of the distinctive characters between them in his description of the latter species (109, p. 149). On this interpretation, while *E. tumefacta* is distinct in this appendage from *E. tuberosa* by the shorter meropodite and propodite, it is separated from *E. cranchi* by the shorter meropodite only. The number of specimens of *E. tumefacta* I have seen, satisfactorily to be regarded as such, and bearing out this character, is very few, and unless the species is extremely local in its habitat, it is difficult to consider it as more than a variety of *E. cranchi*. Dr. Allen's record of it as abundant to the westward of the Eddystone (1) would support the former alternative, but in this case some difficulty arises in the fact that the specimens concerned showed a close similarity to *E. tuberosa*. In the absence of any clear evidence to the contrary, it seems best to retain the species as distinct, though probably it has often been confused with others in records of the genus.

Ebalia tuberosa (Pennant).

At Positions 1, 3 (one), 11 (one), 13 (two), 15 (one), 16 (three), 19 (one), 22 (a few), 28 (one), 31 (a few), 32 (one), 36 (one), 37 (one), 42 (one), 43 (a few), 44 (two), 46 (two), 53 (two), 62 (six), 63 (six).

Depth, 40–50 fath.

INACHIDAE.

Macropodia aegyptia, A. Milne-Edwards.

Single specimens at Positions 43 and 52.

Depth, 43–45 fath.

Macropodia longirostris (Fabricius).

At Positions 4, 7, 10, 20, 43, 45, 49, 52, 59, 60, 64, 66, 67, 77, 78.

Depth, 40–53 fath.

Single or a few specimens occurred in every case, except at 52, where several were obtained. At Position 60 a female was infected with *Sacculina.*

Macropodia rostrata (Linnaeus).

From one to five specimens at Positions 1, 5, 6, 7, 37, 44, 45, 52.

Depth, 40–47 fath.

Only small specimens were recorded at Positions 1, 6, 37, and 44, that at 44 being an ovigerous female.

Inachus dorsettensis (Pennant).

At Positions 1 (several), 3, 4, 5 (two), 7 (one), 9 (one), 13 (three), 14 (one), 18 (two), 20 (one), 31 (a few), 34, 35, 37, 41 (one), 43, 45 (two), 49 (two), 52 (ten), 53, 56 (a few), 59 (a few), 60, 78 (a few).

Depth, 40–49 fath.

At Position 1, four specimens were dressed, severally, with *Lafoëa fruticosa*, *Plumularia catharina*, *Halecium* sp., and *Halichondria* sp. No other record was preserved of examples illustrating this habit.

Inachus leptochirus, Leach.

At Positions 45 (two), 49 (one), 52 (two), 56 (one), 67 (one).

Depth, 47–49 fath.

Distribution: Shetland (Norman, 11); Moray Firth (Gordon, 113); Firth of Clyde (Elliot, Laurie, and Murdoch, 6); western coasts of Devon or Cornwall and Bigbury Bay (Leach, 120); Falmouth (Norman, 130); Channel Islands (Norman, 128); north side of Bay of Biscay (Kemp, 117); N.W. coast of Spain, N.E. of Cape Verde Islands, Azores (Milne-Edwards et Bouvier, 125); Azores (Miers, 122), (Milne-Edwards et Bouvier, 123); Spalato in Adriatic (Heller, 115).

MAIIDAE.

Pisa biaculeata (Montagu).

At Positions 14 (one female with *Sacculina*), and vii (one ovigerous female).

Depth, 42–49 fath. or over.

Hyas coarctatus, Leach.

Single specimens at Positions 1, 14, 32 (ovigerous female), 43, 67.

Depth, 40–52 fath.

PARTHENOPIDAE.

Eurynome aspera (Pennant).

At Positions 1 (three), 6 (one), 10 (one), 11 (one), 31, 32 (one), 34, 35 (two), 36 (three), 37 (two), 38, 43 (a few), 44, 46 (one ovigerous female), 47 (one), 53 (one), 56 (one), 58 (one), 59 (four).

Depth, 40–49 fath.

CANCRIDAE.

Cancer pagurus, Linnaeus.

One large specimen at Position 25, and two specimens at Position 64.

Depth, 46–50 fath.

At the former point the haul was one of eight minutes' duration, made with the triangular dredge, the bottom consisting of shell and gravel mixed with small stones. At the latter point the otter trawl was used for half an hour, and as no stones were touched by this, and few by the dredge haul immediately preceding it, it may be assumed that the ground was soft and comparatively free from them.

Xantho tuberculatus, Couch.

At Positions 9 (one ovigerous female), 28 (one ovigerous female), 33 (one), 36 (one ovigerous female), 44 (one), 58 (one male), 59 (two females), 63 (one), vii (one female), 80 (one).

Depth, 44–50 fath. or over.

Of the three ovigerous females recorded, two (at Positions 9 and 36) were secluded in empty shells of *Buccinum undatum*, and the zoaea larvae hatched out off the last one on the following day.

The species was discovered by R. Q. Couch, who found it repeatedly in the crevices of *Lepralia foliosa* in the deep water in Mount's Bay, Cornwall, but states that it approaches the shore, being found under stones in summer, and breeds in June. Though it has been recorded from Liverpool Bay, and more recently from Cumbrae in Scotland, it is especially characteristic of the extreme south-western British fauna, and even its inclusion among the species of Plymouth Sound, properly speaking, is open to doubt. Garstang (6, p. 339) records its addition to the Plymouth type collection, but with no data as to its locality. An earlier record by Heape (8, p. 170), "Frequent, 4–45 fathoms," included in a list compiled by Bate, involves the same question of locality, since the material concerned is only referred to by the last author in his original report (2, p. 276), as collected "mostly between Bigbury Bay towards the east and the Dodman towards the west," and "within a distance of about twenty miles of the shore in water that has not exceeded fifty fathoms in depth," thus defining the area for the whole list recorded. The point is of some importance because *Xantho tuberculatus* is one of those species which appear to be rather definitely limited in distribution by certain physical conditions associated with the extreme western area of the Channel, outside the influence of which they exist only in diminishing numbers and soon disappear from the fauna.

Distribution: South-west coast of Ireland (Bourne, 3, p. 314); Cumbrae (Patience, 35); Liverpool Bay (Walker, 137, p. 97); between Bigbury Bay and the Dodman, frequent on stony ground in 4–45 fath. (Bate, 2, p. 276); Mount's Bay, Cornwall (Bell, 109); north side of Bay of Biscay (Walker, 139, p. 158); Bay of Biscay, coast of Portugal, Azores, 166–793 m. and between 748 and 1262 m. (Milne-Edwards et Bouvier, 123, p. 33, and 124, p. 32); Bay of Biscay (Koehler, 10); Bay of Biscay, north-west African coast to Cape Verde Islands (Milne-Edwards et Bouvier, 125, p. 93).

The records from Pirano and Lesina in the Adriatic by Heller, (115, p. 69), were found by Bouvier (111) to refer to *Xantho floridus.* The species is not recorded by Norman from the Channel Islands (128).

PORTUNIDAE.

Portunus depurator (Linnaeus).

One specimen at Position 37.

Depth, 43 fath.

Portunus marmoreus, Leach.

One rather small specimen at Position 46. Width of carapace 19 mm.

Depth, 46 fath.

Portunus pusillus, Leach.

At Positions 1 (two; one an ovigerous female), 3 (one ovigerous female), 13 (one), 31 (one), 35 (two), 48 (one), 62 (three; width of carapace, 18, 14, and 11 mm.), 67 (one; width of carapace 17mm.).

Depth, 40–52 fath.

Portunus tuberculatus, Roux.

Single specimens at Positions 35, 43, and 59.

Depth, 43–49 fath.

Distribution: Shetland, abundant in 80–120 fath. (Norman, 11, p. 268); Mediterranean (Costa); Gulf of Naples, rare (Heller, 115, p. 84); Bay of Biscay, 180 m. and between 300 and 400 m. (Caullery. See Koehler, 10); north coast of Spain and Azores, 560 m. (Milne-Edwards et Bouvier, 125, p. 63); Azores, 454 m.; Cape Finisterre and Bay of Biscay, 136–250 m. (Milne-Edwards et Bouvier, 123, p. 25); north side of Bay of Biscay, 75–109 fath. (Kemp, 117, p. 417).

Bathynectes longipes (Risso).

At Positions 46 (one male) and 80 (one immature female).

Depth, 47–51 fath.

Distribution: Cornwall, Swansea, cp. Bell (109, p. 361); Penzance, Mount's Bay, Falmouth, Polperro (cp. Norman, 130, p. 3); Plymouth, near Eddystone (Garstang); and of frequent occurrence in recent years on different Plymouth grounds; Channel Is. (Sinel. See Norman, 128); Genoa, Naples, Sicily; and in the Adriatic, at Quarnero, Lesina, and Lissa, in 30–40 fath.; Black Sea (cp. Heller, 115, p. 89).

Subsequent to the occurrence of the species referred to by Garstang in 1897, it does not seem to have been observed at Plymouth till 1905, when a specimen was found far inside the breakwater, in Millbay Pit. In 1907 it was recorded on the Rame-Eddystone ground and the Mewstone Ledge, and in every year subsequently occasional examples have occurred mostly on the Mewstone Ledge, but also again in Millbay Pit. On the Mewstone Ledge, Mr. Orton tells me he has repeatedly seen it in the crevices of *Lepralia foliosa.*

It is conspicuously absent from Bay of Biscay records.

CORYSTIDAE.

Atelecyclus septemdentatus (Montagu).

At Positions 4 (one), 10 (one), 13 (one), 14 (three), 20 (one), 22 (one), 31 (a few), 32 (one), 34 (a few), 35 (four), 36 (one), 37 (three), 43 (two), 49 (one), 51 (one).

Depth, 40–47 fath.

ARACHNIDA.

PYCNOGONIDA.

Mr. Hodgson kindly identified the species obtained in this group.

Nymphon brevirostre, Hodge.

One specimen at Position 62.

Depth, 50 fath.

Achelia echinata, Hodge.

At Positions 49 (three), 56 (three), 59 (one), 60 (one), 62 (two).

Depth, 47–50 fath.

Endeis spinosus (Montagu).

One specimen at Position 58.

Depth, 49 fath.

BRYOZOA.

As with the rest of the fauna, such of the Bryozoa as could be easily named at sight were recorded on board in the course of the work, and the rest were brought home for examination. The greater part of the latter, and such as presented no difficulty, were then worked out and added to the list. Subsequently Miss Alice Heath kindly undertook to identify the more doubtful or difficult material that remained. In consequence of this, many of the species are absent from her list. Records by Miss Heath are distinguished by the letter H. The others, for which I am responsible, are followed by the letter C. Miss Heath writes the following note on the specimens submitted to her:—

"The greater part of the material sent to me for identification was in a dry state; the remainder was preserved in alcohol. There proved to be 30 genera and 54 species. Twenty-one species are recorded from one station only. The classification and names given are those used in the Plymouth Fauna List (*Journ. Mar. Biol. Assoc.*, N.S., Vol. VII, p. 155). *Lepralia foliosa* was represented by only one small piece worked up into a worm tube. In *Membranipora flustroides* the zooecia fitted rather more closely together, were less oval than in Hincks's illustration, and the spines were represented by three only. On one small zooecium these spines were flattened and glossy; the others were lost, their points of attachment only showing. One species of *Alcyonidium* I have not been able to identify. Zoarium, erect, delicate, transparent, flattened, about 2½ cm. in height by 1 cm. in breadth; attached to a piece of *Pecten* shell; not as firm and opaque as either *A. gelatinosum* or *A. mytili.* Surface smooth. The superficial boundaries of the zooecia could be distinguished, but very littlt of other details. Brown bodies apparently occupied the interior."

AETEIDAE.

Aetea anguina (Linnaeus).

At Positions 9, 49 (H); 80 (C).
Depth, 42–51 fath.

Aetea recta, Hincks.

At Positions 49 (H); 32 (C).
Depth, 42–47 fath.

EUCRATEIDAE.

Eucratea chelata (Linnaeus).

At Positions 12 (H); 62 (C).
Depth, 42–50 fath.

CELLULARIIDAE.

Scrupocellaria scruposa (Linnaeus).

At Positions 35, 47, 49, 56, 64, 80 (H); 4, 36, 59 (C).
Depth, 40–51 fath.

BICELLARIIDAE.

Bicellaria ciliata (Linnaeus).
At Positions 49, 80 (H); 1, 3, 4, 10, 11, 12, 32, 45, 56 (C).
Depth, 40–51 fath.

Bugula avicularia (Linnaeus).
At Positions 4, 32, 45, 62 (C).
Depth, 40–50 fath.

Bugula flabellata, J. E. Gray.
At Positions 4, 43, 49, vii (C).
Depth, 40–49 fath. or over.

Bugula calathus, Norman.
At Position 36 (H).
Depth, 43 fath.

Bugula turbinata, Alder.
At Positions 43, 80 (H).
Depth, 45–51 fath.

Beania mirabilis, Johnston.
At Positions 49 (H); 11, 12, 32, 33, 35, 45, 47, 49, 59, 62, 80 (C).
Depth, 42–51 fath.
On other Bryozoa and on Hydroids: plentiful at 47 and 49.

MEMBRANIPORIDAE.

Membranipora catenularia (Jameson).
At Positions 43, 49, 59, 60 (H).
Depth, 45–49 fath.

Membranipora dumerili (Andouin).
At Position 36 (H).
Depth, 43 fath.

Membranipora flemingi, Busk.
At Positions 11, 36, 45, 59, 62 (H).
Depth, 42–50 fath.

Membranipora flustroides, Hincks.
At Positions 46, 58 (H).
Depth, 47–49 fath.

Membranipora lineata (Linnaeus.)

At Position 51 (H).
Depth, 43 fath.

MICROPORIDAE.

Micropora coriacea (Esper).

At Positions 8, 43, 56, 60, 80 (H).
Depth, 43–51 fath.

CELLARIIDAE.

Cellaria fistulosa (Linnaeus).

At Positions 1, 3, 4, 8, 10, 11, 13, 14, 32, 33, 34, 35, 40, 49, 51, 56, 58, 59, 60, 62, 64, vii, 80 (C).
Depth, 40–51 fath.

This, the most common species of *Cellaria* obtained, seldom occurred in any considerable quantity except at the first three positions above named where, on the fine sandy ground, it was fairly plentiful.

Cellaria salicornioides, Lamouroux.

At Positions 3, 4, 8, 10, 11, 13, 14, 33, 47, 49, 56, 59, 60, 62, vii, 80 (C).
Depth, 40–51 fath. or over.

This species occurred far less frequently than the preceding, but the same general statement applies to it.

Cellaria sinuosa (Hassall).

At Positions 40, 45, 47, 56, 58, 60, 62, 80 (H); 13, vii (C).
Depth, 42–51 fath. or over.

The comparative scarcity of this species, which is common on the Eddystone Grounds, is remarkable. It is possible, however, that it was overlooked at some of the innermost positions.

CRIBRILINIDAE.

Cribrilina figularis (Johnston).

At Position 59 (H).
Depth, 49 fath.

Cribrilina radiata (Moll).

At Positions 8, 11, 12, 38, 44, 45, 49, 56, 59, 60, 80 (H).
Depth, 42–51 fath.

Membraniporella nitida (Johnston).

At Position 59 (H).
Depth, 49 fath.

ESCHARIDAE.

Lepralia foliacea (Ellis and Solander).
At Positions 51 (H); 46, 56, 58, 59, 63, 64, 68, vii, 78, 80 (C).
Depth, 43–51 fath. or over.
Plentiful at Positions 59 and 68.

Chorizopora brongniarti (Audouin).
At Positions 36, 45, 56, 59, 60 (H).
Depth, 43–49 fath.

Porella concinna (Busk).
At Positions 8, 13, 44, 53, 56, 60 (H).
Depth, 42–49 fath.

Porella compressa (Sowerby).
At Positions 36, vii (H); 9, 33, 34, 38, 46, 47, 53, 62 (C).
Depth, 42–50 fath. or over.

Smittia reticulata (Macgillivray).
At Position 36 (H).
Depth, 43 fath.

Smittia trispinosa (Johnston).
At Positions 8, 12, 40, 45, 56, 59 (H).
Depth, 42–49 fath.

Mucronella peachi (Johnston).
At Positions 43, 49 (H).
Depth, 45–47 fath.

Mucronella variolosa (Johnston).
At Positions 8, 51, 58, 72 (H).
Depth, 43–49 fath.

Mucronella ventricosa (Hassall).
At Positions 9, 12, 13, 36, 46, 59 (H).
Depth, 42–49 fath.

Palmicellaria skenei (Ellis and Solander).
At Positions 43, 62 (H).
Depth, 45–50 fath.

Hippothoa distans, Macgillivray.
At Positions 11, 12, 51, 56 (H).
Depth, 42–49 fath.

Hippothoa divaricata, Lamouroux.
At Positions 11, 43, 49, 53 (H).
Depth, 42–46 fath.

Schizoporella johnstoni, Quelch.
At Position 51 (H).
Depth, 43 fath.

Schizoporella linearis (Hassall).
At Positions 9, 38, 43, 44, 46, 47, 49, 56, 72 (H).
Depth, 42–49 fath.

Schizoporella unicornis (Johnston).
At Positions 8, 12, 45 (H).
Depth, 42–47 fath.

Schizoporella discoidea (Busk).
At Position 59 (H).
Depth, 49 fath.

CELLEPORIDAE.

Cellepora avicularis, Hincks.
At Positions 8, 10, 11, 13, 34, 35, 38, 40, 43, 49, 51, 53, 56, 59, 60, 62, 64, 70, 80 (H); 1, 3, 4, 6 (C).
Depth, 40–51.

Cellepora dichotoma, Hincks.
At Positions 10, 36, 49 (H).
Depth, 42–47 fath.

Cellepora pumicosa, Linnaeus.
At Positions 10, 38, 44, 49 (H); 46 (C).
Depth, 42–47 fath.

Cellepora ramulosa, Linnaeus.
At Positions 8, 11, 13, 33, 35, 38, 40, 43, 45, 47, 49, 52, 60, 62, 72 (H); 1, 32, 37, 46, 80 (C).
Depth, 40–51 fath.

Crisia ramosa, Harmer ?
At Positions 40, 49, 52, 56 (H).
Depth, 44–49 fath.

DIASTOPORIDAE.

Diastopora patina (Lamarck).

At Positions 9, 38, 46, 56, 72 (H); 80 (C).

Depth, 44–51 fath. or over.

TUBULIPORIDAE.

Tubulipora liliacea (Pallas).

At Positions 36, 56, 62, 64 (H); 1, 3, 4, 8, 9, 10, 11, 32, 35, 40, 49, 53, vii, 80 (C).

Depth, 40–51 fath. or over.

Entalophora clavata (Busk).

At Position 62 (H).

Depth, 50 fath.

Stomatopora granulata (Milne-Edwards).

At Position 50 (H).

Depth, 49 fath.

Stomatopora johnstoni (Heller).

At Position 13 (H).

Depth, 42 fath.

Stomatopora major (Johnston).

At Position 11 (H).

Depth, 42 fath.

Stomatopora dilatans (Johnston).

At Position 80 (H).

Depth, 51 fath.

Stomatopora deflexa (Couch).

At Positions 11, 13, 60, vii (H).

Depth, 42–49 fath. or over.

LICHENOPORIDAE.

Lichenopora hispida (Fleming).

At Positions 9, 11, 59, 60, 72 (H).

Depth, 42–49 fath.

ALCYONIDIIDAE.

Alcyonidium gelatinosum (Linnaeus).

At Positions 1, 3, 4, 7, 31, 35, 37, 43, 47, 51, 52, 56, 59 (C).
Depth, 40–49 fath.
As single or few colonies in all cases.

Alcyonidium mytili, Dalyell.

At Position 67 (H).
Depth, 52 fath.

Alcyonidium sp.

At Position 40.
Depth, 44 fath.

For description of this doubtful species, see Miss Heath's note at the commencement of this group.

VALKERIIDAE.

Valkeria uva (Linnaeus).

At Position 49 (H).
Depth, 47 fath.

Specimens apparently also belonging to this species were obtained on *Hydroids* and *Cellaria* at Positions 3, 4, 14, 47, 59, and 62, and probably occurred at several other points (C).

PEDICELLINIDAE.

Pedicellina cernua (Pallas).

At Positions 3, 10–14, 32–34, 37, 38, 49, 53, 56, 59, 62, 80 (C).
Depth, 40–51 fath.

Pedicellina gracilis, Sars.

At Positions 11–14, 32, 35, 37, 40, 45, 47, 49, 59, 62, 80 (C).
Depth, 42–51 fath.

MOLLUSCA.

Where not otherwise specified, records refer to living specimens.

AMPHINEURA.

NEOMENIIDAE.

Rhopalomenia aglaopheniae (Kowalevsky and Marion).

At Positions 37 (one), 38 (one), 43 (two), 56 (one); on *Aglaophenia myriophyllum.*
Depth, 43–49 fath.

Myzomenia banyulensis (Pruvot).

At Positions 32 (two), 38 (one), 45, 59 (one), 60 (one); on *Lafoëa dumosa*.

Depth, 42–49 fath.

ISCHNOCHITONIDAE.

Craspedochilus onyx (Spengler).

At Positions 1 (several), 3 (one), 4 (several), 11 (one), 13 (two), 15 (one), 32 (two), 35 (one), 36 (one).

Depth, 40–43 fath.

GASTROPODA.

PROSOBRANCHIATA.

FISSURELLIDAE.

Emarginula fissura (Linnaeus).

Single specimens at Positions 33 and 58.

Depth, 42–49 fath.

TROCHIDAE.

Gibbula tumida (Montagu).

One specimen at Position 33.

Depth, 42 fath.

Calliostoma exasperatum (Pennant)?

A *Trochus* apparently belonging to this species was obtained at Positions 45 (two) and 52 (one).

Depth, 43–47 fath.

Calliostoma montagui (W. Wood).

One dead shell at Position 52.

Depth, 43 fath.

Calliostoma granulatum (Born).

At Positions 32 (one), 52 (two), 60 (one).

Depth, 42–49 fath.

Calliostoma striatum (Linnaeus).

One dead shell at Position 43.

Depth, 45 fath.

Calliostoma zizyphinus (Linnaeus).

At Positions 1 (two), 17 (one), 52 (one), 59 (one), 60 (one).

Depth, 40–49 fath.

CAPULIDAE.

Capulus hungaricus (Linnaeus).

Single dead shells at Positions 1, 7, 41.
Depth, 40–44 fath.

CYPRAEIDAE.

Trivia europaea (Montagu).

Single specimens at Positions 45 and 51.
Depth, 43–47 fath.

The specimen at Position 51, measuring 9·5 mm., had a very smooth, shiny surface, with the ribs but faintly marked, and the spire quite distinct, showing three whorls, thus retaining the young characters to a remarkable degree.

Ovula patula (Pennant).

At Positions 1, 3 (one), 10 (one), 53 (one), 59 (three).
Depth, 40–49 fath.

Erato laevis (Donovan).

One dead shell at Position 1.
Depth, 40 fath.

NATICIDAE.

Natica alderi, Forbes.

At Positions 46 (two dead), 49 (one dead), 52 (two), 60 (one).
Depth, 43–49 fath.

LAMELLARIIDAE.

Lamellaria perspicua (Linnaeus).

At Positions 32 (one) and 59.
Depth, 42–49 fath.

SCALIDAE.

Scala clathrus (Linnaeus).

One specimen at Position 1.
Depth, 40 fath.

Scala turtoni (Turton).

One specimen at Position 36.
Depth, 43 fath.

EULIMIDAE.

Eulima polita (Linnaeus).

Single specimens at Positions 11 and 47.
Depth, 42–47 fath.

TURRITELLIDAE.

Turritella communis, Lamarck.

At Positions 1 (two) and 10 (one).

Depth, 40–42 fath.

APORRHAIDAE.

Aporrhais pes-pelicani (Linnaeus).

One dead shell at Position 1.

Depth, 40 fath.

BUCCINIDAE.

Buccinum undatum (Linnaeus).

At Position 3 (spawn only), 5 (one), 7 (one), 8 (two and spawn), 9 (one), 10 (one), 17 (one), 59 (one).

Depth, 40–49 fath.

The spawn obtained at Position 3 hatched out on the following day.

Tritonofusus gracilis (Costa).

Specimens were obtained at Positions 10 (two), 11 (three), 12 (several), 14 (five), 25 (one), 32 (one), 34 (one), 35 (several), 43 (one), 46 (one), 52 (a few), 58 (one), 59 (one), 60 (one), 67 (one), 72 (five), 80 (one).

Depth, 42–51 fath.

The great majority of these specimens were empty shells, or those occupied by *Eupagurus cuanensis* or *E. prideauxi*, in most cases the former. Living specimens were only recorded at Positions 25 (one), 58 (one), 67 (one), 72 (two), and excepting perhaps those recorded without data at 10 and 34 these constitute the only ones obtained.

Tritonofusus propinquus (Alder).

One specimen at Position 58.

Depth, 49 fath.

This species has not previously been recorded from Plymouth, but three specimens were obtained by the *Huxley* at the north side of the Bay of Biscay in 1906 (Rennel, 148, p. 382). The localities of occurrence given by Jeffreys are: Coasts of Yorkshire, Durham, and Northumberland, Berwick Bay, Aberdeenshire, Hebrides, Shetland; New Brighton, Liverpool; Dublin Bay; Cork; Finmark; Kullaberg; Kattegat; cp. Jeffreys (147, iv, p. 339).

MURICIDAE.

Ocinebra erinacea (Linnaeus).

At Positions 59 (spawn only), and 60 (one shell occupied by *Eupagurus cuanensis*).

Depth, 49 fath.

Trophon muricatus (Montagu).

One shell at Position 6, occupied by *Eupagurus cuanensis*.
Depth, 42 fath.

NASSIDAE.

Nassa incrassata (Ström).

One specimen at Position 44.
Depth, 46 fath.

PLEUROTOMIDAE.

Mangilia gracilis, P. Fischer.

At Positions 13 (one living), and 31 (one dead).
Depth, 40–42 fath.

Clathurella linearis (Montagu).

At Positions 7 (one dead), and 11 (one living).
Depth, 42 fath.

OPISTHOBRANCHIATA.

TECTIBRANCHIATA.

SCAPHANDRIDAE.

Scaphander lignarius (Linnaeus).

At Positions 7 (six), 8 (two), 24, 43 (one), 52 (one); all living except that at 52.
Depth, 42–45 fath.

PLEUROBRANCHIDAE.

Oscanius membranaceus (Montagu).

At Position 1 (one specimen, with spawn).
Depth, 40 fath.

NUDIBRANCHIATA.

AEOLIDIIDAE.

Galvina tricolor (Forbes).

At Positions 6 (one), 45 (five), 52 (several).
Depth, 42–47 fath.

Facelina drummondi (Thompson).

At Position 6 (one).
Depth, 42 fath.

DOTONIDAE.

Doto coronata (Gmelin).

At Position 13 (one).
Depth, 42 fath.

Doto fragilis (Forbes).
At Positions 8 (?) (spawn only), 19 (three), 34 (one).
Depth, 44–45 fath.

DENDRONOTIDAE.

Dendronotus frondosus (Ascanius).
At Position 52 (one).
Depth, 43 fath.

DORIDIDAE.

Goniodoris nodosa (Montagu).
At Position 47 (one).
Depth, 47 fath.

Archidoris tuberculata (Cuvier).
At Positions 4 (four), 7 (one), 78 (one).
Depth, 40–49 fath.

TRITONIIDAE.

Tritonia hombergi, Cuvier.
At Positions 4 (one), 52 (two), 60 (one), vii (one), 70 (one).
Depth, 40–49 fath. or over.

Tritonia (Candiella) plebeia, Johnston.
At Positions 4 (four), 7 (one), 11 (one), 45, 46 (one).
Depth, 40–47 fath.

SCAPHOPODA.

Dentalium entalis, Linnaeus.
At Positions 1 (fifteen), 5 (one dead), 6 (one dead), 10 (one living, two dead), 11 (three living, one dead), 13 (one), 36 (one), 37 (five living).
Depth, 40–43 fath.

PELECYPODA.

PROTOBRANCHIATA.

NUCULIDAE.

Nucula nucleus (Linnaeus).
At Position 1 (seven).
Depth, 40 fath.

FILIBRANCHIATA.

ANOMIIDAE.

Anomia ephippium, Linnaeus.

I have thought it best to include under this one species all the specimens of *Anomia* that were recorded. Though it is possible that *A. patelliformis* occurred among them, it was very difficult to distinguish among the extremely irregular forms assumed by the specimens any definite external characters, such as those assigned to the latter form by Jeffreys (147). The shape and moulding of the valves seemed in all cases to be merely dependent on that of the base of attachment.

Specimens were definitely recorded, sometimes in considerable numbers, at Positions 1, 3, 4, 7–15, 19, 31–36, 43, 44, 46, 49, 52, 53, 56, 59, 60, 64, vii, 72.

Depth, 40–50 fath. or over.

Attached to shells of other molluscs, more frequently *Pecten*, and to other bodies, especially stones on the rougher ground, it was one of the commonest and most generally distributed species that occurred.

ARCIDAE.

Pectunculus glycimeris (Linnaeus).

At Positions 6, 7, 10, 14, 16, 17, 19, 32, 33, 36, 37, 43, 44, 46, 51, 53, 58.

Depth, 40–49 fath.

At Position 7, only old valves occurred. Excepting at Positions 10, 14, 16, 17, 19, and 43, the specimens obtained were all of a remarkably small size.

Arca tetragona, Poli.

At Positions 34, 43 (two), 55, vii (one).

Depth, 42–49 fath. or over.

MYTILIDAE.

Volsella modiola (Linnaeus).

At Positions 1 (one dead), 11 (one living).

Depth, 40–42 fath.

Volsella barbata (Linnaeus).

At Position 4 (one).

Depth, 40 fath.

Volsella phaseolina (Philippi).

At Positions 4, 6, 8, 10, 11, 32, 33, 36, 37, 38, 40, 43, 45, 49, 51, 53, 58, 60, 64, vii.

Depth, 40–50 fath. or over.

From one to six specimens were recorded at the several positions, measuring from 3 to 9 mm. in length.

Modiolaria marmorata (Forbes).

At Positions 1 (one), 3 (two), 4 (three), 44 (one), 58 (one), 59 (one), 80 (one).

Depth, 40–51 fath.

Though this species was occasionally found buried in the tests of Ascidians, most of the specimens recorded occurred free. One was attached by the byssus to the base of a colony of *Cellaria*.

PSEUDOLAMELLIBRANCHIATA.

PTERIIDAE.

Pinna fragilis, Pennant.

Pairs of empty valves, or single valves or fragments of such, occurred at Positions 7, 8, 10, 13, 20, 28, 35, 49, 52, 66, 68, vii, 78, 80.

No living specimen was obtained.

Depth, 42–52 fath. or over.

PECTINIDAE.

Pecten maximus (Linnaeus).

At Positions 1 (empty shells), 7 (a few), 8 (one), 10 (one living, a few dead), 11 (one), 12 (three), 14 (one), 20 (a few), 30 (a few), 43 (one young), 45 (two), 47 (one), 52 (one), 59 (two), 60 (three), 62 (one), 68 (three), 80 (several dead).

Depth, 40–51 fath.

Pecten pusio (Linnaeus).

One dead valve at Position 46, and one small living specimen at the doubtful Position vii.

Depth, 47–49 fath. or over.

Pecten varius (Linnaeus).

One young specimen at Position 7.

Depth, 42 fath.

Pecten opercularis (Linnaeus).

The numerical proportion in which this species was obtained may be compared as follows:—

Few or very few specimens at Positions 1, 5 (small), 6, 9, 10, 11, 12, 18, 25, 37, 40, 41, 43, 44, 46 (small), 58 (small), 60 (small), 68 (small).

Fairly plentiful at Positions 3, 14, 20, 30, 31, 35, 52 (about fifty, many quite small), 63 (small), 72.

Abundant at Positions 7, 8, 49.

Dead specimens were obtained for the most part at Positions 10 and 37, and exclusively at Positions 13 (many), 47 (small), 51 and 80 (many).

The variety *lineata* was recorded at Positions 7 (few), 8 (several), 43 (one), 60 (one).

Specimens were recorded with both valves unicolorous at Positions 40 (purple), and 60 (chrome-yellow).

Depth, 40–51 fath.

Pecten tigerinus (Müller).

At Positions 1 (one), 6 (one valve), 7 (one), 13 (one), 31, 32 (several), 33 (one), 34, 43 (few), 44 (one).

Depth, 40–46 fath.

LIMIDAE.

Lima hians (Gmelin).

At Positions 44, 58 (four), vii (one).

Depth, 46–49 fath. or over.

Lima loscombi, G. B. Sowerby.

At Positions 6 (one dead valve, bored), 32 (one), 44 (one), 62 (one), 80 (one).

Depth, 42–51 fath.

EULAMELLIBRANCHIATA.

ASTARTIDAE.

Astarte sulcata (da Costa).

At Positions 9 (one), 11 (one), 15 (one), 16 (three), 19 (one), 32 (a few), 34, 35 (one), 36 (one), 37 (one), 40 (one), 44 (one small), 53 (one), 56 (one).

Depth, 42–49 fath.

CYPRINIDAE.

Cyprina islandica (Linnaeus).

A single living specimen was obtained at Position 39.

Dead specimens occurred at Positions 10 (a few), 12 (several), 13 (one), 20 (several), 44 (one).

Depth, 42–46 fath.

LUCINIDAE.

Lucina borealis (Linnaeus).

One young specimen at Position 1.
Depth, 40 fath.

Montacuta substriata.

At Position 46, attached to *Spatangus purpureus.*
Depth, 46 fath.

LEPTONIDAE.

Kellia suborbicularis (Montagu).

At Positions 1, 11 (two), 32 (two), 38 (two).
Depth, 40–44 fath.

SCROBICULARIIDAE.

Syndosmya prismatica (Montagu).

Three specimens at Position 1.
Depth, 40 fath.

TELLINIDAE.

Tellina crassa (Gmelin).

At Positions 17 (one living), 53 (one overgrown valve).
Depth, 45–46 fath.

MACTRIDAE.

Spisula elliptica (Brown).

At Positions 5 (two), 6 (three dead valves, one bored), 58 (one).
Depth, 42–49 fath.

Lutraria elliptica, Lamarck.

One dead valve bored by *Cliona*, at Position 11.
Depth, 42 fath.

VENERIDAE.

Dosinia exoleta (Linnaeus).

One young specimen at Position 5.
Depth, 42 fath.

Dosinia lincta (Pulteney).

At Positions 1 (one dead), 9 (three single valves), 10 (three living, one dead), 11 (one dead), 13 (one dead).
Depth, 40–42 fath.

Venus fasciata (da Costa).

At Positions 40 (one), 44 (one), 46 (two), 53 (one dead).
Depth, 44–46 fath.

Venus casina, Linnaeus.

At Positions 6 (one dead valve), 9 (four living, one dead valve), 10 (one living, several dead), 11 (one), 12 (one), 13 (one), 16 (two), 17 (three), 19 (one), 34 (a few), 44, 46 (two young), 53.

Depth, 42–46 fath.

Venus ovata, Pennant.

At Positions 1 (one young), 6 (one dead valve), 10 (one), 40 (one), 43 (two), 44 (one).

Depth, 40–46 fath.

Tapes virgineus (Linnaeus).

At Positions 1 (three young living, one dead), 6 (one bored valve), 12 (one dead), 20 (one living), 43 (two dead), 53 (two dead), 56 (one dead).

Depth, 40–49 fath.

Gouldia minima (Montagu).

At Positions 6 (one dead valve), 43 (three), 44 (several).

Depth, 42–46 fath.

CARDIIDAE.

Cardium echinatum, Linnaeus.

At Positions 1 (old valves), 70 (one living).

Depth, 40 fath.

Cardium norvegicum (Spengler).

At Positions 5 (one young), 10 (one), 19 (one), 20 (dead valves), 51 (two large, living).

Depth, 42–45 fath.

Cardium tuberculatum, Linnaeus.

One young specimen, 9 mm. in length, apparently belonging to this species, was obtained at Position 53.

Depth, 46 fath.

GARIDAE.

Gari costulata (Turton).

Single specimens at Position 10, 31, 37.

Depth, 40–43 fath.

Gari ferroensis (Chemnitz).

One dead valve at Position 1.

Depth, 40 fath.

Gari tellinella (Lamarck).

One dead, at the doubtful Position vii.
Depth, between 49 and 53 fath.

SOLENIDAE.

Cultellus pellucidus (Pennant).

Two specimens at Position 1.
Depth, 40 fath.

SAXICAVIDAE.

Saxicava arctica (Linnaeus).

From one to about a dozen specimens were recorded at Positions 3, 4, 7, 11, 14, 32, 33, 37, 40, 43, 47, 53, 59, 62, 64, 72.
Depth, 40–50 fath.

PHOLADIDAE.

Pholas sp.

Old borings of a doubtful *Pholas* occurred in limestone at Position 46.
Depth, 47 fath.

Pholadidea sp.

An unidentified species of *Pholadidea* occurred, boring in sandstone, at Position 34.
Depth, 42 fath.

LYONSIIDAE.

Lyonsia norvegica (Chemnitz).

One pair of dead valves at Position 36.
Depth, 43 fath.

CEPHALOPODA.

LOLIGINIDAE.

Loligo media (Linnaeus).

One specimen at Position 7.
Depth, 42 fath.

SEPIIDAE.

Sepia elegans, d'Orbigny.

At Positions 3 and 60 (one).
Depth, 42–49 fath.

Sepia officinalis, Linnaeus.

At Positions 7 (one), 60 (one).
Depth, 42–49 fath.

Sepia sp.

Two records under the generic name only, of single specimens that were subsequently lost, occurred at Positions 1 and 68.

Depth 40–52 fath.

SEPIOLIDAE.

Sepiola atlantica, d'Orbigny.

One specimen only was recorded at Position 6.

Depth, 42 fath.

POLYPODIDAE.

Moschites cirrosa (Lamarck).

One specimen at Position 8.

Depth, 43 fath.

TUNICATA.

By

Dr. R. Hartmeyer.

CAESIRIDAE [MOLGULIDAE].

Eugyra glutinans (Möller).

At Positions 1 (one), 6 (one), 10 (three), 37 (two).

Depth, 42–43 fath.

Caesira [Molgula] simplex (Alder and Hancock).

At Positions 1 (one), 3 (four), 7 (seven), 8 (one), 10 (two), 11 (two), 12 (three), 31 (one), 32 (two), 34 (one), 49 (six), 70 (one).

Depth, 40–47 fath.

Caesira [Molgula] oculata (Forbes).

At Positions 11 (one), 33 (one), 44 (one).

Depth, 42–46 fath.

PYURIDAE [HALOCYNTHIIDAE].

Pyura [Halocynthia] savignyi (Philippi).

At Positions 3 (one), 4 (one), 8 (one), 15 (one), 34 (four), 43 (three), vii (two).

Depth, 40–49 fath. or over.

TETHYIDAE [STYELIDAE].

Pandocia [Polycarpa] singularis (Gunnerus).

At Positions 1 (seven), 3 (seven), 4 (two very large, many smaller, including a number quite young), 7 (three), 8 (six), 9 (one), 12 (one), 49 (one), 59 (three), 60 (one), 70 (many examples associated with *Ascidiella aspersa*), 72 (two), vii (six, including one young).

Depth, 40–49 fath. or over.

Pandocia [Polycarpa] comata (Alder).

At Positions 1 (one), 4 (one young), 10 (two, including one young ?), 31 (two), 53 (one), vii (one).

Depth, 40–49 fath. or over.

BOTRYLLIDAE.

Botrylloides rubrum, Milne-Edwards.

At Positions 3 (one), 4 (one), 8 (one), 38 (one).

Depth, 40–43 fath.

Polycyclus polycyclus (Savigny).

At Positions 3 (two), 4 (one), 7 (one), 8 (one), 49 (one), 60 (one), 64 (two).

Depth, 40–53 fath.

Certain colonies of a *Polycyclus* I refer to the *Botryllus polycyclus* of Savigny, and to the form from the Channel, not to that from the Mediterranean. Herdman has referred colonies from the Irish Sea likewise to this form of Savigny's, but has given them a new name, *P. savignyi*. This new naming seems scarcely justified, even if—as I agree with Herdman in doing—one separates specifically the North-west European form from the Mediterranean form. The latter bears the name *P. renieri*, Lam. *P. polycyclus* (Sav.) is partly a synonym of this species (Mediterranean form). For the North-west European specimens this name *P. polycyclus* (Sav.) still stands. *P. savignyi* (Herdman) is purely a synonym of it. The largest of the colonies (Fig. 1) forms a flattened extended mass, of which the anterior border is divided into a number of blunt lobes, while the posterior end is strongly narrowed with a stalk-like extension. This stalk-like process evidently serves for the attachment of the colony.

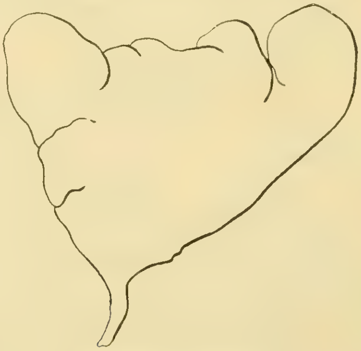

FIG. 1.—*Polycyclus polycyclus* (*Sav.*) × $\frac{2}{3}$.

The colony is 67 cm. in maximum breadth, 51 cm. in length, and 1·3 cm. in thickness. To Herdman's description I further add that the meshes contain, counted from the endostyle, ca. 8, ca. 5, ca. 4, ca. 6 stigmata, and the stomach possesses a prominent caecum bent into a hook shape.

RHODOSOMATIDAE [CORELLIDAE].

Corella parallelogramma (Müller).

At Positions 3 (one), 10 (one), 60 (one).
Depth, 40–49 fath.

Corella larvaeformis, Hancock.

At Positions 32 (one), 38 (one).
Depth, 42–44 fath.

PHALLUSIIDAE [ASCIDIIDAE].

Ascidiella aspersa (Müller).

At Positions 1 (three, including a smooth example of the type *virginea*, of which, however, the course of the gut conforms with that of the type *aspersa*), 3 (seven), 4 (eight), 5 (one), 7 (one), 10 (one), 32 (three), 33 (three), 34 (two), 40 (one), 42 (one), 70 (in great abundance in and upon *Pecten* shells, or massed together), 72 (one young).
Depth, 40–44 fath.

Phallusia [Ascidia] virginea, Müller.

At Positions 1 (one), 3 (one), 8 (one), 12 (one), 15 (one), 34 (one), 38 (one), 40 (one), 43 (one), 59 (two), 60 (one), 67 (one), 70 (two), 72 (three), vii (one).
Depth, 40–52 fath. or over.

Phallusia [Ascidia] mentula (Müller).

At Positions 3 (two), 4 (three), 8 (two), 12 (one), 34 (one young), 40 (one), 59 (one).
Depth, 40–49 fath.

Phallusia [Ascidia] conchilega (Müller).

At Positions 1 (one), 4 (one), 8 (one), 10 (three), 32 (one), 34 (two), 36 (one), 37 (two young), 43 (four), 49 (one), 70 (one), vii (two).
Depth, 40–49 fath. or over.

I refer the species *depressa* to the older specific name *conchilega*. Among the material two examples occur which in some characters, especially in the course of the alimentary canal, differ from the typical specimens. That from Position vii (Fig. 2) measured on the body (excluding the test) 3·6 cm. in length and 2·6 cm. in height. The anterior end is narrowed and bluntly rounded; the posterior end, on the contrary, is more than usually broadened. The whole animal has evidently undergone a shortening in the long axis. One consequence of this shortening at least is the almost horizontal position of both loops of the intestine and the situation of the anal opening as high as the upper curvature of the intestine, whereby the unusual course of the latter is occasioned. The test is beset with conspicuously large prominences, which in their form recall those of *Ascidiella aspersa* (Müller). The other specimen (Fig. 3), from Position 8, likewise shows certain peculiarities.

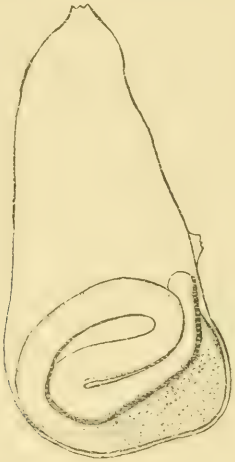

FIG. 2.—*Phallusia conchilega* (Müll.), Interior × 2

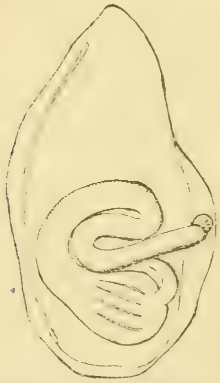

FIG. 3.—*Phallusia conchilega* (Müll.), Interior × 2.

Such are the pronounced oval form, and the likewise very strongly bent loops of the intestine, although the anus retains its position below the upper curve of the latter. The free surface (the animal is attached by the whole left side of the body) is finely cornulated.

CIONIDAE.

Ciona intestinalis (Linnaeus).

At Positions 3 (two), 4 (one), 10 (one), 12 (one), 34 (two), 40 (one), 44 (one), 49 (two), 59 (many massed together), 67 (one), 70 (many on the inner surface of *Pecten* shells or massed together).

Depth, 40–52 fath.

DIDEMNIDAE.

Didemnum [Leptoclinum] perspicuum (Giard).

At Position 3 (two).

Depth, 40 fath.

Leptoclinum [Diplosoma] gelatinosum, Milne-Edwards.

At Positions 1 (one), 3 (one), 4 (two), 59 (one).

Depth, 40–49 fath.

CEPHALOCHORDATA.

Amphioxus lanceolatus (Pallas).

At Positions 5 (one), 11 (one), 21 (one), 48 (five), 50 (one), 57 (eight), 58 (three).

Depth, 42–49 fath.

VERTEBRATA.

PISCES.

The infrequent use of the trawls must be borne in mind with reference to the comparatively few fishes recorded.

ELASMOBRANCHII.

SCYLLIIDAE.

Scyllium canicula (Linnaeus).

One specimen at Position 7.

Depth, 42 fath.

RAIIDAE.

Raia clavata, Linnaeus.

Single specimens at Positions 8 and 66.

Depth, 44–52 fath.

Raia circularis, Couch.

At Positions 49 (one), and 66 (three).

Depth, 47–52 fath.

Raia sp.

Examples of *Raia* not specifically recorded occurred at Positions 3 (one), 7 (three), 8 (one).

Depth, 40–43 fath.

TELEOSTEI.

MURAENIDAE.

Conger conger (Linnaeus).

One specimen at Position 64.

Depth, 53 fath.

GADIDAE.

Gadus luscus, Linnaeus.

At Positions 3, 7 (two), 68 (thirty-two), 78 (six).

Depth, 40–52 fath.

Gadus minutus, Linnaeus.

At Positions 3, and 49 (several).

Depth, 40–47 fath.

Gadus pollachius, Linnaeus.

One specimen at Position 59.

Depth, 49 fath.

Molva vulgaris, Fleming.

One specimen at Position 3.

Depth, 40 fath.

Motella tricirrata, Nilsson.

At Positions 58 (one), and vii (one).

Depth, 49 fath. and (?) over.

SERRANIDAE.

Serranus cabrilla, Linnaeus.

At Positions 8 (one), 49 (three).

Depth, 43–47 fath.

Fishes obtained at Positions 64 (one), and 68 (four), which were not retained, probably also belonged to this species.

CAPROIDAE.

Capros aper (Linnaeus).

At Positions 3 (three), 7 (a few), 8 (one), 49 (a few), 59 (one), 60 (two), 64 (two), 68 (eighty-five), 78 (two).

Depth, 40–52 fath.

The haul at Position 68, where the large number of this species occurred, was one of fifty-five minutes with the otter trawl, taken in 52 fathoms. It was one of the few cases in which the otter trawl was used, with some risk, in the neighbourhood of decidedly rough ground.

PLEURONECTIDAE.

Zeugopterus norvegicus (Günther).

At Positions 52 (one), 59 (one), 60 (one). Length, 6·9, 10·3, and 5·7 cm. severally.

Depth, 43–49 fath.

A *Zeugopterus* which occurred at Position 58, probably also belonged to this species.

Arnoglossus laterna (Walbaum).

At Positions 3 (one), 7 (a few), 8, 49 (eight), 52 (one), 60 (three), 64 (three), 68 (six), 78 (four).

Depth, 40–53 fath.

Arnoglossus megastoma, Donovan.

At Positions 3 (a few), 7 (two).

Depth, 40–42 fath.

Pleuronectes microcephalus, Donovan.

At Positions 7 (one), 49 (one), 68 (three).

Depth, 42–52 fath.

Solea variegata (Donovan).

At Positions 35 (one), 51 (one), 52 (three), 68 (one).

Depth, 43–52 fath.

GOBIIDAE.

Gobius jeffreysi, Günther.

At Position 1 (one), 52 (one).

Depth, 40–43 fath.

Gobius scorpioides, Collett.

At Positions vii (one), 62 (one). Length, 33 mm. and 31 mm. respectively.

Depth, 50 fath. and (?) over.

Mr. Boulenger kindly identified this rare goby. With reference to its occurrence, Holt and Byrne (152, p. 21) state that excepting several specimens obtained from Ballynakill Harbour on the west coast of Ireland, there are only five records of its capture, viz. from the Norwegian coast, the Cattegat, Falmouth, and 30 miles W.N.W.

of Cleggan Head, the depth of occurrence ranging from about 2 to 74 fath.

The two specimens here recorded considerably exceed in length the measurement, "less than 1 inch," given by Holt and Byrne.

AGONIDAE.

Agonus cataphractus, Linnaeus.

At Positions 5 (one), 52 (one). Length of the latter specimen 40 mm.

Depth, 42–43 fath.

Callionymus lyra, Linnaeus.

At Positions 3 (a few), 7 (two), 8 (one); 59 (two), 60 (three), 66 (one), 68 (one).

Depth, 40–52 fath.

TRIGLIDAE.

Trigla pini, Bloch.

At Positions 3 (one), 7 (a few), 8 (one), 49 (four), 60 (three small), 64 (two), 68 (five).

The small specimens at Position 60 measured 6·4, 5·6, and 5·3 cm. severally, in length.

Depth, 40–53 fath.

Trigla lineata, Gmelin.

Two specimens at Position 49.

Depth, 47 fath.

TRACHINIDAE.

Trachinus draco, Linnaeus.

Only recorded at Position 7.

Depth, 42 fath.

GOBIESOCIDAE.

Lepadogaster bimaculatus, Fleming.

One specimen at Position 1.

Depth, 40 fath.

Lepadogaster microcephalus, Brook.*

One specimen at Position 72.

Depth, 43 fath.

LOPHIIDAE.

Lophius piscatorius, Linnaeus.

One specimen at Position 64.

Depth, 53 fath.

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Some Notes upon the Feeding Habits of Mackerel and certain Clupeoids in the English Channel.

By

G. E. Bullen.

SEVERAL previous authors* have shown that the food of the mackerel, when in coastal waters, is of two different kinds, and that the fish adopts two distinct methods of procuring it. In the first place it feeds by a system of filtration upon planktonic organisms, and secondly upon prey of a larger character which is hunted by sight.

The exact nature of the food taken whilst the fish is in its winter quarters has not as yet been thoroughly investigated; but the present writer, in making examination of the stomach contents of mackerel taken on the ground in March, 1907, 25 miles S.W. of Start Point, found that it consisted entirely of zoo- and phytoplankton of a nature similar to that existing in the water itself.† A close similarity in general character appeared to exist between the nature of these samples and others from fish taken in the Bristol Channel at the surface during the early part of April of the same year.‡

It was also observed that during the three months forming the more important part of the "drifting" season in the western area, viz. April, May, and June, the fish were feeding exclusively upon plankton, and that the nature of this food gradually changed from being largely vegetable to almost wholly animal.

It was not until the middle of June that food of a larger character, but still wholly of the latter type, began to appear in stomach contents, and it is a well-known fact that at about this time every year the drift fishery in the area under consideration begins to decline, and hand-lining commences. This condition is due to the fact that the dense shoals break up, and the system of nutrition, which has hitherto been one of filtration, gives place to one of, what we may term, "selective feeding."

From the evidence before us, in the form of the plankton results for the stations E5 and E6 (the only two falling within the fishing area), published in the *Bulletins Conseil International pour l'exploration de la Mer*, it would appear that these several changes in the nature of the food of the mackerel, viz. from phytoplankton to general zooplankton, and from thence to zooplankton of a larger character and animal food generally, e.g. young fishes and material offered as bait, is largely, if not entirely, due to seasonal changes in the nature of the food supply itself. Yet, as it has been abundantly shown that certain planktonic organisms are of sporadic distribution, and that there is some fair evidence to show that others occur in shoals of varying extent, it remains to be seen how far the mackerel, exercising these two distinct methods of nutrition, is capable of discriminating between varying types of food during the period that it is feeding by filtration.

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* *Vide* Allen, E. J., "Rep. on the Present State of our Knowledge with Regard to the Habits and Migrations of the Mackerel," *Journ. Mar. Biol. Assoc.*, N.S., Vol. V, p. 9.

† "Plankton Studies in Relation to the Western Mackerel Fishery," *Journ. Mar. Biol. Assoc.*, N.S., Vol. XVIII., pp. 285–6.

‡ *Id.* Table No. IV, Nos. 76 to 83, and Table No. V, No. 111.

The question arises, to begin with, whether in adopting the one system the fish is incapable of using the other, and two important points in this connection may be considered. In the first place, the Newlyn drifters state emphatically that it is impossible to take mackerel, when closely shoaling, upon a hand-line; and secondly, it is a matter of common knowledge amongst fishermen that, when late in the summer mackerel are caught (in drift nets), when feeding heavily upon copepods, they are very liable to rapid decomposition in the region of the stomach, and that this is due to the "soft" condition of the fish themselves, and not to the increased warmth of the atmosphere. Now, with respect to this matter it may be stated that the present writer, in making examination of the stomach contents of several hundreds of mackerel taken at various times of the year, has invariably found that the walls of the stomach appeared to be contracted and thickened in cases where phytoplankton formed the bulk of the food, whereas the organ in question was distended and the walls extremely thin when zooplankton occurred. Moreover, although no careful histological comparison was made between the two types, it was found possible to distend, by means of an air-pump, to a great extent an empty stomach of the latter type without undue pressure, whereas one of the thickened type would not respond to such treatment. Again, throughout an observation extending over nearly six years upon fish in many cases from not exactly determined sources, the writer has found that, with very few exceptions, the thinning of the stomach walls is developed to the greatest extent as the western drift fishery approaches its highest point of productiveness, viz. in May and June in the case of large mackerel, and in June and July with those of smaller size, which latter, as Dr. Allen* has pointed out, appear to be solely on feeding migration. Moreover, in all of the early spring "hooked" mackerel that the writer has examined, the walls of the stomach have been of fair thickness.

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* *Op. cit.*, p. 25.

The evidence before us is certainly insufficient to warrant an assertion that a physiological change is brought about in the nature of the stomach by reason of a change of diet, but the fact remains that the writer has found it possible invariably to determine the *general* nature of the food contained in the stomach of a mackerel or a pilchard from an external examination of the organ itself, before it is opened.

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With reference to the transitional stage from the one type of feeding to the other, the following note, received in the autumn of 1911 from Mr. Mathias Dunn, of Newlyn, is of considerable interest. This observer states:—

"I sent you yesterday some specimens of a rare Crustacean *Macropsis*, which has been very abundant on our coasts this summer. The mackerel have been feeding ravenously on these animals, and at times have pursued them into the harbour, where they have been so numerous as to appear like thick porridge. We have had some excellent opportunities of seeing mackerel feed, during the visit of these little creatures. They have been hunting up and down the back of the pier, like a pack of hounds, going the whole length, turning and returning again and again. They were swimming about ten to twelve feet off the pier in company with a number of scads, about twenty to thirty in each shoal, the scads in every case swimming close to the pier and the mackerel just outside. The mackerel were swimming in open order, closing in, rising and falling in graceful undulations, by which means they either drove their prey on to the surface, where there was no escape, or turned it to the centre of the shoal, where it was also promptly despatched."

Upon examination, the sample sent by Mr. Dunn was found to consist almost entirely of the Mysid Crustacean *Macropsis stabberi*, Van Beneden,* together with a few young Herring (surface-swimming stage), and a slight number of fish ova and the Copepod *Centropages typicus*, Kröyer.

Unfortunately no stomach material was examined, but the foregoing observations tend to show amongst other things that the fish were feeding by sight, and were exercising discrimination in the selection of their prey. At the time when these observations were made, however, viz. in July, the heavy summer drift fishery was far on the decline* and line fishing had commenced, an indication that the fish had begun to take prey of larger type.

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* For the determination of this species the writer is indebted to Mr. W. M. Tattersall, M.Sc.

With further reference to the feeding habits of mackerel and herring, in this instance kept in captivity at the Brighton Aquarium, the writer is indebted to Mr. E. W. Cowley, the Superintendent, for the following note.

This observer states: "The herring and mackerel are usually taken from the sea in October and November with the seine net, which is drawn on to the beach. They are then conveyed to the Aquarium in cans the size of an ordinary sanitary bin, about 20 or 30 in each can. Special care is taken to see that the cans are not overcrowded, the fish are not handled in any way, and conveyed to the tanks with the greatest possible speed. Even with these precautions we consider ourselves fortunate in saving 10% of the original catch. After they are placed in the tanks great care has to be exercised to see that the fish are in no way disturbed until they are acclimatized; but we have not found it necessary to darken the tanks.

"In the case of the herring and mackerel we find that the placing of a rock in the centre of the tank assists them considerably, unless of course a tank 120 feet long is provided.

"We feed both species upon sand-hoppers and small shrimps, alive if possible, and vary the diet from time to time with whiting cut up into small pieces. Of course great care has to be used not to overfeed them.

"The feeding is done at regular times, viz. 12 noon and 4 p.m. I have repeatedly noticed that the fish seem to know the time of feeding, for at these hours they are always on the alert. Before the food falls to the bottom of the tank it is devoured, and even when only a few shrimps or sand-hoppers are left, the fish will dart hither and thither after them.

"Usually we keep the herring and mackerel in separate tanks, but since last month (i.e. October, 1911) we have had them mixed, and I notice that they are swimming intermingled.

"During the summer months they both swim nearer to the surface than in the winter, but they never seek the bottom, being continually in motion, night and day. Otherwise there is no difference in their summer and winter movements. The temperature of the water in the tanks, which hold about 3000 gallons, is not so variable, I should think, as that of the open sea.

"Usually the mackerel live about two to three years, but we have kept herring from four to five years. No examples have ever been measured or weighed, but certain of both species appeared to have reached sexual maturity before they died. The greatest mortality with both herring and mackerel takes place during the summer, and this may be due to the small quantity of water in the tanks, which are furnished, however, with air tubes, which continually circulate the water, day and night."

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* *Vide* "Weekly Market Reports," *Fish Trades Gazette.*

From personal observation of some mackerel which had recently been installed in one of the tanks at the Brighton Aquarium in October, 1910, the present writer would estimate the average length to be not more than 9 inches. In this connection it may be noted that Cunningham* states that the smallest ripe specimens which he had examined were 11·6 in. to 12·9 in. long.

In specimens measuring about 9 in. in length, seined at Sidmouth in 1911 towards the end of July, the writer observed no sexually mature fish, and the same condition obtained in several shoals taken by the seine at Brighton in October, 1909–10. It is fair to suppose, therefore, that the mackerel forming the subject of Mr. Cowley's observations were not sexually mature fish when placed in the tanks, and according to Cunningham† about a year old.

Now, although it may be urged that observations taken upon fishes acclimatized to the abnormal conditions obtaining in an aquarium are open to question, certain points of interest present themselves when Mr. Cowley's remarks are considered. In the first place, it will be seen that mackerel and herring *can* exist, for a reasonable period, all the year round upon food of a type similar to that which is hunted by sight—we may almost say food of a more solid character than plankton. Secondly, although the mackerel is known to be an active swimmer and voracious feeder, its appearance as it moves leisurely round the tank at a pace of not more than two miles an hour when no disturbing influence is present, might suggest that it is either aware of the fact that the tank water does not support sufficient plankton to form a good meal, or that it is indifferent to it in view of the fact that it knows that food of a more solid nature is offered to it at regular intervals.

Returning to the opening question raised in the first paragraph, it may be suggested that here is further evidence to show that mackerel, feeding by sight upon prey of a large character, are incapable of taking nourishment by means of filtration.

Mr. Dunn's observations tend to show that the larger plankton organisms are hunted by the mackerel by sight, the fish thereby exercising a selective capability.

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* Cunningham, *Mark. Mar. Fishes*, p. 315.

† *Id.*

To what extent this power, on the part of the fish, to discriminate between food of a wholesome character and that which is otherwise—what we have termed "selective feeding"—is carried, may now be considered.

The writer, in a previous paper,* has remarked upon the finding of alternating layers of certain species of zooplankton, in almost pure condition, in stomach material. The same thing has been recorded in the case of the Irish mackerel.†

The explanation of this condition originally suggested was to the effect that the fish might have been feeding first in a shoal of plankton organisms of one type and then in another, or else in different layers of water.

Prof. Ehrenbaum, of Heligoland, upon hearing of this theory, informed the writer that he had on certain occasions observed herring and mackerel, which were kept alive in tanks, showing unmistakable signs of feeding by selection upon individual copepods and other plankton organisms.‡

Further, it may be mentioned that the present writer, in making exhaustive examination of several hundreds of stomachs of mackerel and pilchard (of the former for the purposes of the paper already cited), was never able to detect any sign of the presence of medusae. Dr. Allen, however,§ in summarizing published information regarding the food of the mackerel, states: "In the first place, it feeds upon the smaller forms of the plankton, e.g. copepods and other crustaceans, larvae of crustaceans, molluscs, echinoderms and worms, diatoms and even *siphonophores* and *medusae*."|| That this may be food of a somewhat exceptional character is evidenced by the fact that mackerel and

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* *Op. cit.*, p. 274.

† Farran, *Rep. on Sea and Inland Fisheries, Ireland*, 1901, Pt. II, p. 122.

‡ In reply to an enquiry respecting this statement Prof. Ehrenbaum wrote: "With reference to your enquiry, I desire to state that in the Heligoland aquarium mackerel, and at certain times also young herring, are kept alive for months, and both species have often been observed feeding in the manner described.

"Personally (and in this statement I think I have the support of many biologists), I consider that it cannot be doubted that all fish, which prey upon plankton, *feed by selection*. This can easily be demonstrated by an investigation of the stomach contents. Such material is never found to consist of all the various plankton components occurring within the area from whence the fish have been taken, but includes only certain species, which have been selected by the feeding fish.

"In my opinion it is a fallacy that certain fish, e.g. the mackerel, habitually swim round with an open mouth. The filtering apparatus of the gill arches is not intended to collect the plankton about to be swallowed, but serves to protect the tender gill-leaflets from possible damage caused by spurious forms of the plankton, which might occasionally be taken in the act of breathing into the mouth."

§ *Op. cit.*, p. 9.

|| The italics have been inserted.

pilchard drift-fishermen at Newlyn, Mevagissey and elsewhere contend that good catches are seldom made in water which "brimes" considerably. On one occasion at Mevagissey an old fisherman, on seeing several *Hormiphora plumosa* drop from the first net of a fleet shot for pilchard, informed the writer that he knew that there would be a poor catch, which subsequently proved to be the case. The explanation, however, which was given, was to the effect that these ctenophores, becoming caught up on the meshes, rendered the nets conspicuous by their phosphorescence.

It may be mentioned, moreover, that boats fishing further out to sea made fair catches, and it is possible that these ctenophores occurred abundantly, as is often the case, in the estuarine water flowing out of the harbour, and in the fairly still water in the immediate vicinity.

The above statements constitute our sole direct evidence of the extent to which the theory of selective feeding in mackerel and certain other drift fishes can be carried. We may therefore summarize some other points which may lend further support to the suggestion.

There is a fair amount of evidence to show that mackerel, herring, and pilchard are continually in a state of voluntary movement when engaged upon inshore migration.

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With mackerel, the opinion is generally held by fishermen that once fish are known to be congregated in certain areas, unproductive fishing is due to the fact that the fish are not at the surface. The continued prevalence of N. and N.W. gales is well known to have a marked effect upon the western fishery, even at its height. The slight knowledge which we now possess respecting this fish's winter habitat* would strengthen the idea that it would naturally seek deeper layers of water, when the surface was subject to inclement conditions of atmosphere.

Mr. Cowley's statement, already cited, that mackerel and herring kept in captivity are continually in motion night and day, is quite in accordance with the views held by several intelligent fishermen, questioned on the subject by the present writer.

Moreover, the bare fact of the gradual progression shoreward of mackerel spread over a wide area at the beginning of the fishing season, resulting in a concentration of many thousands of shoals within the comparatively limited area afforded by the most productive fishing waters of May—i.e. within a 50-mile radius to the S. and S.W. of Scilly—would, to a great extent, preclude the suggestion that the fish are much affected in their inshore movements by the influence of currents.

* *Vide* A. Cligny, "*Les pretendus migrations du maquereau.*" Ann. Sta. Aquicole, Boulogne-sur-mer, Nouv. Ser., Vol. I, 1905.

In the present state of our knowledge with regard to the winter habitat of the species, it is impossible to even hazard a suggestion as to how far many of these fish, caught in the height of the season, have travelled, yet the fact remains that productive fishing is carried on nearer and nearer to land as the season continues.

It is a somewhat difficult matter to obtain precise information with regard to the rate of progression of a single shoal of drift fish. Mathias Dunn, senior, stated that this in the case of pilchards, when on migration, was about 1½ miles an hour.*

Some information gathered at Sidmouth in 1911, moreover, may be worthy of record. The writer was informed by two boatmen who were constantly sailing over the area under consideration, that a shoal of small mackerel was first observed off Start Point at the beginning of July. It passed too far out from Dartmouth and Exmouth to be taken in a seine, but was fished for by certain drifters within a few miles from land. The shoal finally came close inshore to the west end of the seafront at Sidmouth, where the greater part were taken in a seine, the remnant passing farther to the east. The time occupied in covering the total distance (which in a straight line is about 33 miles) was stated to be about nine days.

From a consideration of the above statements, several questions pertinent to the question of selective feeding naturally arise. In the first place, it may be suggested that when once distinct migration commences, whether it be a "spawning" or a "feeding" migration, mackerel make more or less regular daily progress towards inshore waters in the area under discussion, their movement being undeterred by the influence of currents. If this be the case, it naturally follows that were the fish to swim vigorously forward in the indiscriminate pursuit of plankton, at a pace sufficient to enhance the catching power of the mouth, their progress toward the land would be considerably more rapid than it appears to be from the slender evidence before us.

The speed, at which the small mackerel already mentioned crossed Torbay and the adjacent water, appears to have been about three to four miles a day. From observations made at Sidmouth by the present writer upon fish of this type in the years 1910–11, the food consisted for the greater part of caradid larvae with a few copepods, certainly, on the whole, organisms which might have been hunted by sight. How did these fish, therefore, take so long in covering the distance cited, unless whilst maintaining a shoal formation they were continually rounding up their prey in ceaseless movement, similar to that described by Mr. Mathias Dunn, whilst at the same time travelling by almost imperceptible stages toward land?

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* Dunn, M., "Some Habits of Picked Dogs, Herrings and Pilchards," 54*th Ann. Rep. Royal Cornwall Polytechnic Soc.*, p. 5.

Again, if it can be suggested with any degree of certainty that a plankton organism such as a caradid larva, which is considerably smaller than the mysid *Macropsis*, is hunted by sight—by a system of selective feeding—it is a difficult matter to determine how small an organism may be before a mackerel ceases to feed upon it with discrimination.

The present writer in a former paper* has shown that a marked correlation appears to exist between the extent of the inshore migration of mackerel during the three months constituting the more important period of the drift-fishing season in the western part of the English Channel, viz. April, May, and June, and the paucity or abundance of the zooplankton occurring in the same area.

These observations, considered collectively, would tend to show that mackerel prefer an animal to a vegetable diet, and that it is probable, with a thorough understanding of the seasonal changes occurring in the pelagic plankton of the area under consideration, it may be demonstrated that shoaling mackerel frequent, in greater numbers, those areas supporting a food supply most suited to their taste. There is considerable evidence, moreover, in support of a theory that shoals of mackerel, when entering swarms of wholesome planktonic organisms, feed ravenously upon them while they last, whilst refraining from food to a great extent when swimming in water containing, what we may suppose to be, organisms of a distasteful character. It naturally follows that in years when the coastal waters support in greater proportion food of an inferior type, the extent of the inshore migration of mackerel is largely retarded.

The question naturally arises—Can this condition be traced to the fish's own capability of discrimination in question of food? Can it also be urged that if mackerel are capable of hunting, presumably by sight, the larger forms of the zooplankton, they are also able to discern when in sufficient numbers dense shoals of the more minute forms such as the copepod *Calanus finmarchicus* Gunnier and others, thereby still exercising a system of selective feeding, though in this case in a more expansive sense, viz. the obtaining of large mouthfuls of suitable plankton by a selection of the type of water supporting such prey, whenever possible.

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To summarize briefly the deductions which may be drawn from a consideration of the above observations, it may be stated—

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* *Op. cit.*, p. 278 and onward.

(*a*) That not only mackerel, but herring also can exist for a reasonable period of time, whilst exercising a system of nutrition by selective feeding, irrespective of season.

(*b*) That this system of selective feeding in mackerel and scad may extend to the larger forms of the plankton.

(*c*) That whilst it is impossible to determine how far the mackerel is assisted in its search for food by its power of vision, there is strong presumptive evidence to show that a capability for selective feeding, in a wider sense, may be extended to comparatively minute organisms, when they are present in sufficient numbers.

(*d*) And that this capability on the part of the fish to discriminate between food of a wholesome and that of a presumably unwholesome nature, would cause it to seek in greatest numbers water supporting the most suitable type of food, the extent of inshore migration thereby being largely dependent upon the planktonic condition of the coastal waters.

(*e*) Finally, that there is a by no means negligible amount of evidence to show that, when feeding upon the minor forms of the plankton, mackerel are incapable of assimilating other larger prey—which theory, if more fully established, would lend further support to the deduction that there is necessity for a suitable and abundant supply of plankton in the inshore waters before the shoals are induced to approach the land in sufficient numbers to form a profitable fishery.

In the preparation of this paper the writer's thanks are due to Mr. Mathias Dunn and Mr. E. W. Cowley for their valuable observations, also to Dr. E. J. Allen for much assistance and advice.

On the Occurrence of a Northern Hydroid *Halatractus* (*Corymorpha*) *nanus* (Alder) at Plymouth.

By

Dr. E. Stechow, München.

With Plate VII and Figure 1 in the Text.

On looking over some hydroid material, for which I have to thank the Biological Station at Plymouth, I found upon an alga that was thickly covered with *Eudendrium album*, Nutting,* between the stalks of the Eudendrium a single specimen of the rare *Halatractus* (*Corymorpha*) *nanus* (Alder), which has until now been considered an Arctic species. The specimen is of special interest owing to the fact that this form has only been exceptionally met with in subarctic waters, and has only been recorded in England as a special rarity from the colder coast of Northumberland [Hincks, 1868; Allman, 1872; Pennington, 1885]. As far as can be gathered, it has only been found once even there. Its discovery now at Plymouth, on the warm southern coast washed by the Gulf Stream, is therefore the more surprising. In the comprehensive list of the Marine Fauna of Plymouth in this Journal (N.S., Vol. VII, pp. 155–298, 1904) the species is not included.

Corymorpha nana. Alder, Catalogue of Zoophytes of Northumberland and Durham. Trans. Tyneside Nat. Field Club, Vol. III, p. 108, Pl. 9, Figs. 7–8. 1858.

Corymorpha nana. Hincks, A History of the British Hydroid Zoophytes, p. 130, Pl. 22, Fig. 3. 1868.

Halatractus nanus. Allman, Monograph Tubularian Hydroids, p. 391. 1872.

Corymorpha nana. Pennington, British Zoophytes, p. 78. 1885.

Corymorpha nana. Bonnevie, Hydroida, Norske Nordhavs Expedition, p. 22, Pl. 1, Fig. 7. 1899.

Corymorpha nana. Bedot, Matériaux, 2^me^ période. Revue Suisse de Zoologie. Tome 13, Fasc. 1, p. 63, 1905.

Corymorpha nana. Broch, Hydroiden der arktischen Meere. Fauna Arctica, Bd. 5, Lfg. 1, p. 194. 1909.

Halatractus nanus. Bedot, Matériaux, 3^me^ période. Revue Suisse de Zoologie. Tome 18, Fasc. 2, p. 304. 1910.

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* *Jour. Mar. Biol. Assoc.*, N.S., IV, p. 146, 1896, and *Ann. Mag. Nat. Hist.*, 7 ser. Vol. I, p. 362, Pl. 14, Fig. 1, 1898.

The specimen agrees fairly well with the descriptions of Alder, Hincks, and Allman as completed by Bonnevie (1899). Nevertheless, I give here an accurate drawing (Plate VII), since it differs from the *figure* given by Hincks in many details, and the species has, indeed, never been adequately figured. The base is unfortunately broken off. The whole individual has a length of 3·5 mm.; the lower diameter of the hydranth, measured between the bases of the tentacles, is 0·8 mm.; the aboral tentacles are about 1·5 mm. long. The specimen is a young one, as can be seen by the immature condition of the gonophores. These show the beginning of the invagination of the Entocodon ("Glockenkern"), with as yet no trace of a differentiation into the characteristic medusoid organs (Fig. 1). The gonophores are simple and *unbranched;* they do *not* hang in bunches, as is characteristic of *Corymorpha nutans*, the only species of *Corymorpha* previously found at Plymouth. There is also no indication that these gonophores could be transformed at a later stage of their development into branched blastostyles. Besides, they stand in their circle not singly and uniformly distributed, but for the most part crowded near together in small groups. The hydranth has eighteen aboral and sixteen oral tentacles; but the number of the aboral tentacles especially is still increasing, as is shown by four very small tentacles, which I found in addition to those enumerated above between the large ones.

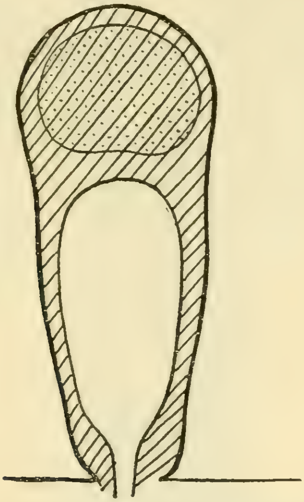
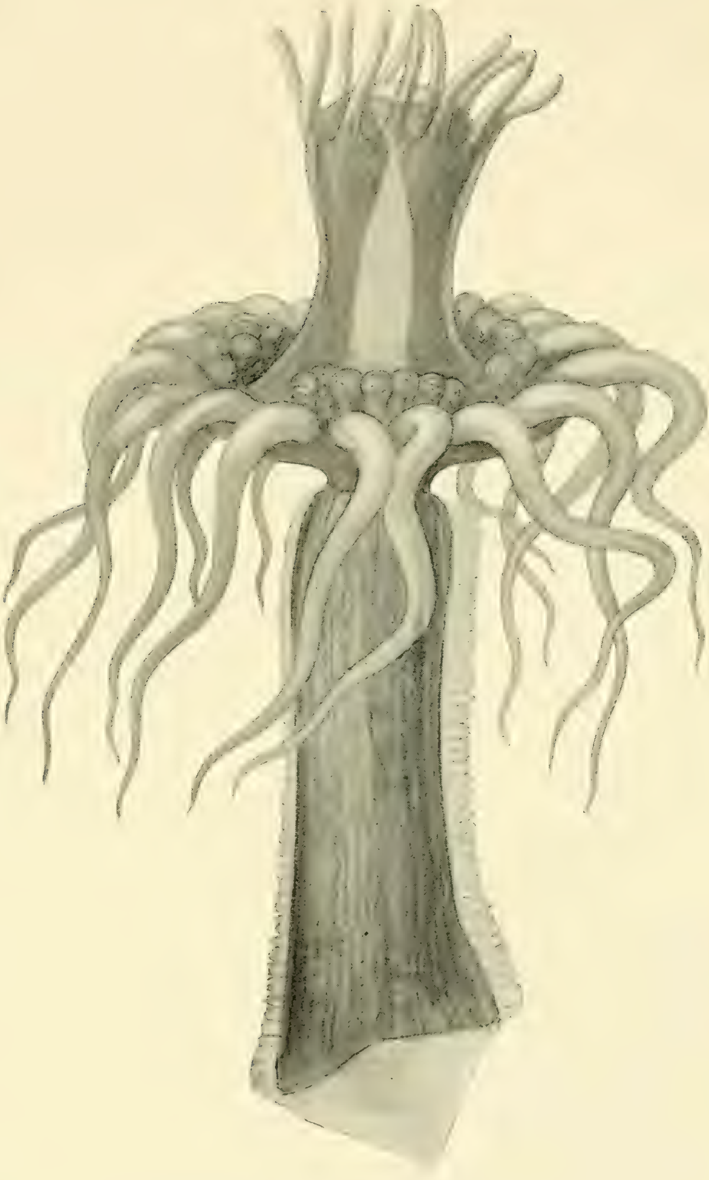


FIG. 1.—*Halatractus nanus* (Alder). Blastostyle (Diagrammatic, with outline drawn from actual preparation. The "Glockenkern" is dotted).

The hydranth is very sharply separated from the hydrocaulus. This is not accurately represented in Hincks's figure, which shows incorrectly a gradual transition at this place. Below the hydranth there is a deep *constriction;* the hydrocaulus which follows this begins with a slight thickening, which causes the constriction above it to appear still more obvious. I find it difficult, therefore, to understand how this characteristic constriction could have escaped the older authors. This is the chief point of difference which I find as compared with Hincks's figure, but it does not seem to me sufficient to found a new species.

The periderm is membranous, and encloses the hydrocaulus to the top; in this upper part however it is not closely attached, but lies loosely around it. In the interior of the hydrocaulus below the surface a longitudinal striation can be clearly recognised, due to the longitudinal canals present in all the *Corymorphas.*

In spite of certain differences when compared with the accounts of previous authors, I think that this form may certainly be identified as *Halatractus nanus* (Alder). Its transportation by a ship, under the circumstances in which it was found, is also improbable. There remains, therefore, only the supposition that its normal distribution really extends as far south as Plymouth, and that it is only on account of its rarity that it has not been previously found.



HALATRACTUS (CORYMORPHA) NANUS (ALDER).

List of Nemerteans collected in the Neighbourhood of Plymouth from May–September, 1910.

By

Dr. Gerarda Wÿnhoff.

With Figure 1 in the Text.

THE following list is one of the results of my work during a stay of nearly four months at the Plymouth Laboratory of the Marine Biological Association. I desire to express my thanks to the Director and the Staff of the Laboratory for the interest they took in my work and for their kind assistance.

A few of the Nemerteans, recorded in the list of the Plymouth Marine Invertebrate Fauna, published in 1904, were not found. For example, *Cephalothrix linearis*, which was dredged by Riches outside the Breakwater, has never been found again, notwithstanding all the trouble taken in searching for it. *Amphiporus bioculatus, McIntosh*, known from one specimen only from a dredging in Millbay Channel, I have not seen, nor the two new species of the genus *Oerstedia* described by Riches as *O. nigra* and *O. immutabilis*. To the forms missing in my list I must add *Malacobdella grossa*, *Baseodiscus curtus*, *Oxypolia beaumontiana*, *Micrella rufa*, and *Cerebratulus pantherinus*. With the exception of the two *Oerstedia* species each of the above species has been found in single specimens on rare occasions. Instead of these nine species however, I can add nineteen which have not yet been recorded from Plymouth; the greater part of these are new to England or the Atlantic Ocean, and four are new species.

As to the system accepted in this list, I have followed neither Bürger nor Coe. Bergendal's investigations on *Carinoma* and my own studies on the family *Cephalotrichidae* resulted in the breaking up of Bürger's ordo *Mesonemertini*. Bergendal's work has revealed many peculiarities in *Carinoma*, which prove its near relationship to the *Tubulanidae*. Moreover certain anatomical features remind us very much of the *Heteronemerteans*. The *Cephalotrichidae* are quite typical *Protonemerteans*, but do not possess any character suggesting an intermediate position between the other members of this group and the *Metanemerteans*. Both genera have therefore been replaced in Bürger's ordo *Protonemertini*, which means the restoration of Hubrecht's *Palaeonemertini*.

Certainly *Hetero-* and *Palaeonemertini* are much more closely related to each other than the *Metanemerteans* with either of them. The position of the mouth behind the brain, the structure of the alimentary canal, the tendency to a complicated structure of the body wall, the development of an outer longitudinal muscle layer, the presence of an inner circular muscle layer of which traces may be found at least in every family, the structure and position of the cerebral organs and the position of the nervous system, which only secondarily migrates through the outer circular muscle layer, together with the absence of any structure in the proboscis, which reminds us of its peculiar complication in the ordo *Metanemerteans*, are so many points of resemblance, that I do not hesitate to join *Palaeonemertini* and *Heteronemertini* together in one order, the ordo *Anopla* of Max Schultze.

Bürger's *Metanemertini* = Hubrecht's *Hoplonemertini* constitute my second order, for which Max Schultze's name *Enopla* ought to be restored. They are characterised by the situation of the mouth in front of the brain, the presence of an oesophageal diverticulum, the structure of the body-wall, the peculiar structure of the proboscis and the presence of stylets, the position of the nervous system in the parenchyma of the body, the situation and structure of the cerebral organs, the uniformly built vascular system.

Palaeonemertini and *Heteronemertini* have been reduced to the rank of suborders. The nomenclature of "Das Tierreich" has been adopted.

As iconographical works I have everywhere referred to:

1. *Bürger, O.* Die Nemertinen des Golfes von Neapel. Fauna und Flora. Monogr. 22, 1895.

2. *Joubin, L.* Les Némertiens. Faune française par R. Blanchard et J. de Guerne. Paris, 1894.

3. *McIntosh.* A Monograph of British Annelids. Part I. Nemerteans. Ray Society, London, 1873–1874.

ORDO I. ANOPLA.

In addition to the outer circular and the inner longitudinal muscle layers an outer longitudinal and an inner circular muscle layer may be present. The nervous system is situated in the body wall. Mouth always behind the brain. No diverticulum of the oesophagus. No stylets and no peculiarly built proboscis.

SUBORDO I. PALAEONEMERTINI.

Lateral nerves and brain nearly always situated outside the muscular body-wall. The body-wall consists of an epithelium, a circular muscle layer and an inner longitudinal muscle layer; the inner circular muscle layer may be absent.

I. FAM. TUBULANIDAE, Bürger.

Cerebral organs nearly always present; the cephalic furrows merely consist of epithelial grooves. Often with lateral sense-organs. Nervous system situated between the epithelium and the basal membrane or between the basal membrane and the outer circular muscle layer. The epithelium is very thick and contains many clusters of secretory cells. Inner circular muscle layer present. A median dorsal blood-vessel is not present.

GENUS **Tubulanus.**

The nervous system is situated between the basal membrane and the muscular body-wall. Cerebral organs present.

1. **Tubulanus polymorphus** (*Ren.*). (Bürger. Monogr. Taf. I, Fig. 4; Joubin. Les Némertiens, Pl. I, Fig. 8 et 9.)

Locality: Eddystone and Rame-Eddystone Grounds; once off the Breakwater.

A few specimens of this Nemertean were always dredged in the deep water near the Eddystone or on the Rame-Eddystone Grounds, at a depth of 45 m. or more. No external markings are present; the body has a uniform orange colour and is rather soft. The head is separated from the body; it is much broader and rounded. Lateral organs are present.

Geographical distribution: Norway, England, France (both coasts), Mediterranean coasts.

2. **Tubulanus linearis** (*McIntosh*). (Bürger. Monogr. Taf. I, Fig. 2.)

Locality: Several specimens known from different localities inside the Breakwater (Queen's Grounds, Asia Shoal, Millbay Pit, Duke Rock). Shallow-water form.

The head and oesophageal region of this Nemertean are milk-white; the other part has an orange-brown tint. This is due to the intestine. The head is very flat, and in the living animal very often makes a burrowing movement. Notwithstanding the perfect transparency of this part I have not been able to distinguish the cerebral organs or cephalic slits. The rhynchodaeum is conspicuous as a milk-white line in front of the brain commissures, which are very long; the brain lobes are but small and do not approach each other at all. The proboscis sheath does not extend into the hinder part of the body; it is, however, present at the beginning of the intestinal region.

Geographical distribution: Southern coast of England, Wimereux, Naples.

3. **Tubulanus miniatus** (*Bürger*). (Bürger. Monogr. Taf. I, Fig. 8.)

Three individuals of a Nemertean which I consider identical with the one specimen described by Bürger from Naples, were dredged on the Rame-Eddystone Grounds on July 11th. Depth 45–55 m.

By its size this species is easily distinguished from *T. polymorphus*, the length of the biggest specimen being 3 cm., at a breadth of 1½ mm. Moreover, the colour of the body is a darker orange than *T. polymorphus* possesses at Plymouth; the rounded head is not so broad, and is not so sharply separated from the body; it has a white patch at its tip. Generally the dorsum has a more intense colour than the ventral side; the dorsal and ventral regions are sharply separated by a line which is particularly well seen in preserved specimens. Alcohol specimens do not take the peculiar marking described by Hubrecht for *T. polymorphus*. Side organs are probably present.

Geographical distribution: One specimen known from Naples (Bürger).

4. **Tubulanus nothus** (*Bürger*). (Bürger. Monogr. Taf. I, Fig. 12.)

Locality: Rum Bay, Bridge and Queen's Grounds, each one specimen; from Asia Shoal and Millbay Pit, each three specimens.

This species, which resembles *T. annulatus* very closely, but is of smaller size, is a shallow-water form at Plymouth. The colour is darker, especially on the back. The ventral side has an orange-brown tint, which continues in a dirty yellow at the head and the tail. On the dorsum a black pigment seems to be developed, which gives the whole animal a dirty brown appearance. The head is colourless with two characteristic black, semicircular pigment spots. It is not broader than the body. The first white ring is present directly behind the colourless head; the median dorsal line takes its origin from it; it is one of the broader belts which very often quite characteristically break up into two thin rings. The lateral lines originate from the second belt; a ventral longitudinal line was present in most of my specimens. Side organs exist; they are to be found as small orange pits at the dorsal side of the lateral lines, just in front of the fourth circular line. Forty rings or more are present, which show in part the arrangement described by Bürger.

The presence of a median ventral line is the only difference between the Naples specimens and my species. Sometimes the ventral line, however, was very inconspicuous, even invisible in the living specimens, while all alcohol material, even those specimens I collected as undoubtedly *T. nothus*, show clearly the presence of this line. Therefore I do not hesitate to regard my species as identical with *T. nothus*, Bürger.

Geographical distribution: It has only been described from Naples by Bürger.

5. **Tubulanus superbus** (*Köll*). (Bürger. Monogr. Taf. I, Figs. 5, 7, 9, 11.)

Locality: On the Eddystone and Rame-Eddystone Grounds; often met with. One specimen from Asia Shoal.

This Nemertean seems to be common on all grounds outside the Breakwater at a depth of 45 m. or more. A small number of individuals has been recorded from more shallow water; both Punnett and Beaumont found it in a sandbank in the river Yealm. Joubin and Bürger give a depth of 30–80 m., which agrees with the ordinary habitat of this worm at Plymouth. The colour of this big Nemertean is a reddish brown. There are four longitudinal white lines and a great number of white rings. The head is broader than the body. Pigment spots are not to be seen. The median dorsal line continues to the tip of the snout, which itself is surrounded by white lines. The cephalic grooves are situated at a short distance behind the first transverse dorsal line. Side organs are present.

Geographical distribution: Mediterranean coasts, Sweden, Great Britain, French coasts of the Channel.

6. **Tubulanus annulatus** (*Mont.*). (Joubin. Les Némertiens, Pl. I, Fig. 2 et 3. McIntosh. Monogr. Pt. I, Pl. 8, Fig. 1.)

Locality: This Nemertean has been recorded from nearly all dredging grounds inside and outside the Breakwater; more commonly it is met with near the Mewstone and the Eddystone, at a depth of at least 18 m.

T. annulatus can easily be distinguished from *T. superbus* by the absence of a median ventral line, its much smaller size and the bright orange-red colour. The white median dorsal line continues on the head and bifurcates at the tip, enclosing a patch of the same colour as the body. The head is coloured both on its dorsal and ventral side; the lateral lines originate from the first white belt, which is situated at a short distance behind the cephalic grooves and just behind the mouth. The cephalic grooves reveal exactly the same features as in *Carinella aragoi, Joubin.* "Ils occupent le fond du cou, et sont, non en creux, mais en relief; ils sont teintés en jaune. Sur la face ventrale, ils commencent audessus de la bouche, de chaque côté, mais sans se rejoindre sur la ligne médiane. Ils sont, dans toute cette portion, à peu près droits. Arrivés sur le bord latéral, dans le prolongement des lignes blanches dont il a été question plus haut, on aperçoit un petit orifice. Au delà, ils passent sur la face dorsale et forment des sinuosités tout à fait caracteristiques. La terminaison des deux sillons forme deux lignes séparées par la bande blanche dorsale" (Joubin. 1890. "Archives de Zoöl. expér. Ser. II, T. VIII, p. 495).

As far as I can judge from the description and the figures given, *T. annulatus, Montagu,* which is doubtless the same species which I found at Plymouth, agrees completely with *C. aragoi, Joubin,* in external features. However, we cannot at present consider the species identical, as their anatomy is not at all the same. This seems to be a case like the one described by Bergendal for *Carinella linearis* and *C. groenlandica.* Neither do the Plymouth specimens agree with the description and figures of Bürger's species in the Naples monograph.

C. annulata, Bergendal, however, seems to exhibit the same internal structure as the Plymouth specimen; but this species differs externally from *C. aragoi* as Bergendal states. This complicates the question still more. Only the study of sections of all these Nemerteans can throw more light on this interesting question. At any rate there can be little doubt as to the identity of *T. annulatus* (*Mont.*) with the Nemertine described above.

7. **Tubulanus albocapitatus.** *Nov. spec.*

Locality: Rame-Eddystone Grounds.

In 3 different dredgings, each time one specimen of this small Nemertean, which can easily be mistaken for a young *T. annulatus,* was collected. On closer inspection it differs considerably from that form. A complete individual had a length of 1½ cm. and was ½ mm. broad in the oesophageal region. The head is not sharply separated from the body, nor is it much broader. Pigment spots are absent. The perfectly white head is followed by a brown-red belt of the same breadth, which is the darkest part of the whole body. A yellow pigment is distributed all over this region. The cephalic furrows are situated in this ring; they are rather deep and reach half-way to the dorsum; they are not lined with white or yellow, as is the case in *T. annulatus,* and are quite differently shaped. The first circular white line separates this region from the body. The median dorsal line, which is white too, passes through this belt into the dark region described above, but does not reach the white head. At both sides of this median longitudinal line, separated from it by a translucent region, a reddish-brown stripe of a fainter tint is present. These stripes do not even reach the lateral lines, as a transparent region is developed between them too; the white pigment patches, which are dispersed at the sides, constitute a very inconspicuous and incomplete lateral line. The ventral side is also trans-

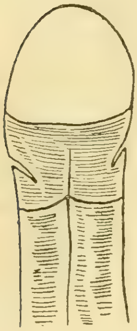


Fig. 1.
Tubulanus
albocapitatus.

parent. Eleven white belts are present; the first constituting the separation between the intense coloured and the oesophageal region. Just in front of the second ring one pair of white patches is conspicuous; they are connected with this belt and are situated in the dorsal red stripes. I have not found any trace of side organs.

II. FAM. CALLINERIDAE.

Cerebral organs absent. Nervous system situated between the basal membrane and the outer circular muscle layer. A thick nervous layer is present in the head. Inner circular muscle layer present. A median dorsal blood-vessel fails; four blood-vessels in the head. Rhynchodaeum with a separate layer of longitudinal muscle fibres. Proboscis anteriorly, with four longitudinal muscle bundles, followed by a diaphragm.

GENUS **Carinesta.**

No composite gland cells in the epithelium. Oesophageal nerves paired; no lateral sense organs. Diagonal muscle layer absent. Proboscis attached behind the mouth. Proboscis sheath without any peculiarities of musculature.

1. **Carinesta anglica.** *Nov. spec.*

Locality: one specimen was collected from the river Yealm at low tide by digging in a muddy sandbank; and one fragment crawling about in sand from Whitsand Bay.

This white nemertine somewhat resembled Punnett's description of *Oxypolia beaumontiana.* The snout is elongated and pointed; when contracted the wrinkling is obvious. Colour a watery milk-white anteriorly; the gonads give the posterior part a rosy-brown tint. The mouth had been protruded obviously in the fragment from Whitsand Bay. No sense organs are present, nor could I distinguish the proboscis pore. The proboscis itself and the intestinum are easily visible because of the transparency of the animal.

The posterior part of the body was much swollen and contracted at irregular intervals when the animal was first examined; on touching it broke into pieces.

Sectioning revealed the very interesting structure of this animal, which I was able to identify as a *Carinesta* species. From Punnett's type specimen, however, which was collected at New Britain, it differs in the total absence of that part of the inner circular muscle layer, which is already disappearing in *C. orientalis.* Moreover, a head gland exists in *C. anglica* and fails in Punnett's specimens. I could not find any traces of a dorsal decussation of fibres, nor is there any special longitudinal muscle sheath at the ventral side of the oesophagus.

III. FAM. CEPHALOTRICHIDAE.

Bodywall composed of an epithelium in which a separate layer of gland-cells does not exist, the basal membrane, the outer circular and the inner longitudinal muscle layer. The inner circular muscle layer often fails. The nervous system is situated in the middle of the inner longitudinal muscle layer. Sense organs are not developed. Four thick cephalic nerves. Vascular system consisting of a pair of lateral blood-vessels only. A great number of nephridial organs.

GENUS **Cephalothrix.**

Mouth widely separated from the brain. Body thread-like. No sense organs. The oesophageal nerves are not paired. No bifurcation of the continuation of the dorsal brain lobes. An inner circular muscle layer fails. The genital sacs are not developed in the oesophageal region.

1. **Cephalothrix rufifrons** (*Johnston*). (Bürger. Monogr. Taf. II, Fig. 24.)

Locality: Common between tidemarks at Rum Bay, Mount Edgcumbe, Drake's Island, the Mewstone; in clean sand, between corallines, under stones, etc. Very thin, colourless or white species, with two small red or orange spots on the tip of the head. Length, 30–40 mm.; breadth, ½ mm.

Geographical distribution: Coasts of Norway, Denmark, Great Britain, France, and Italy.

SUBORDO II. HETERONEMERTINI.

The body-wall is composed of the epithelium, cutis, outer longitudinal, outer circular and inner longitudinal muscle layers. The nervous system is situated between these muscle layers. The lateral nerves are always found outside the circular muscle layer.

I. FAM. BASEODISCIDAE (= Eupolidae, Bergendal).

Proboscis pore near the tip of the snout. The inner muscular layers are not developed in the head. Cerebral organs large, close to the brain. A thick layer of connective tissue separates the epithelium with its gland cells from the outer longitudinal muscle layer. Proboscis with two layers, an outer circular and an inner longitudinal. Proboscis without muscular crosses. The proboscis sheath is short. Head more or less rounded; usually with eyes.

GENUS **Poliopsis.**

Head sharply separated from the body by a deep furrow. A dorsal and a ventral median longitudinal cephalic furrow are present.

1. **P. lacazei,** *Joubin.* (Joubin. Les Némertiens. Pl. I, Fig. 15 et 16.)

Locality: One specimen from the Eddystone.

On the 26th of May I got this single specimen, together with *Tubulanus superbus* and *T. polymorphus*, from the Eddystone Grounds. As the position of the eyes, the bright pink colour and the two cephalic slits agreed perfectly with Joubin's description, I did not hesitate to identify my specimen as *P. lacazei*. The internal structure proved the correctness of this identification.

Geographical distribution: Joubin found this species at Banyuls, Bürger at Mauritius, Hallez near Calais.

II. FAM. LINEIDAE.

Usually with a pair of deep horizontal cephalic furrows. Proboscis with three muscular coats and mostly with two muscular crosses. Cephalic gland consisting of very slender tubes, situated anterior to the brain.

SUB-FAMILY A. LINEINAE.

Without caudal cirrus. Proboscis sheath usually much shorter than the body.

GENUS **Lineus.**

Body rounded or flattened, unusually long, very contractile. Head mostly somewhat broadened and spathulate. The worms are not able to swim; as a rule they coil themselves up and make knots. Ocelli present in most species. Proboscis sheath short.

1. **Lineus longissimus** (*Gunn.*) (McIntosh. Monogr. Pl. IX.)

Locality: Rather common in dredgings from the Sound, Mewstone, and the Yealm.

The colour is a blackish brown relieved throughout by the fine purplish "iridescence of the cilia." With darker and lighter stripes on the head and part of the body. Eyes numerous, arranged in a marginal row on each side of the head, which is somewhat broadened and spathulate, not separated from the body.

Geographical distribution: Atlantic and Baltic coasts of Europe.

2. **Lineus bilineatus** (*Ren.*). (Joubin. Les Némertiens, Pl. II, Fig. 26 et 27.)

Locality: Very common, especially in dredgings from the Sound; from the Rame-Eddystone Grounds, the Mewstone neighbourhood, but also from the Cattewater and between tidemarks at the Yealm and Rum Bay.

Colour a pale brown, sometimes with a reddish shade, or nearly white. With a pair of longitudinal white streaks, passing on from the tail to the tip of the head, where they usually join together in a broader white patch. Head ending bluntly, somewhat spathulate. Eyes wanting.

Geographical distribution: Sweden, Great Britain, France, Italy, Madeira.

3. **Lineus lacteus** (*H. Rathke*). (Joubin. Les Némertiens. Pl. II, Fig. 23; and McIntosh, Monogr. Pl. V, Fig. 3.)

Locality: Two specimens from Asia Shoal, on one occasion.

Body slender, threadlike, white, anteriorly pinkish. Head broadened, spathulate, not distinctly separated from the body. Eyes about fifteen, arranged in a row on each side of the snout. Mouth removed from the brain. Length 100 mm., breadth 1 mm.

Geographical distribution: The Channel, Sweden (?), Mediterranean, and Pontic coasts.

4. **Lineus ruber** (*Müll.*). (McIntosh. Monogr. Pl. V, Fig. 2.)

Locality: Between tidemarks very common in Cawsand and Rum Bay, at Drake's Island; from New Grounds in dredgings.

Body flattened, 3 mm. broad, diminishing towards the tail. Colour usually bright red. Head spathulate, separated from the body. With four to twelve eyes. Length 150–200 mm.

Geographical distribution: Coasts of the Northern Atlantic, with Baltic, Mediterranean, and Madeira coasts.

GENUS **Euborlasia.**

Body very thick, biconvex in section and usually not flattened ventrally. Lateral margins absent after preservation. Head not separated from the body. In animals not perfectly extended the posterior part of the body is much thicker (3–6 times) than the anterior region. Proboscis sheath short. Without eyes.

1. **Euborlasia spec.**

To this genus I refer two fragments of Nemerteans, which were collected from a sandbank in the river Yealm. As in both fragments the anterior portion of the body is wanting, I have not been able to identify the species, or even the genus with certainty. One fragment came living into my possession. It had been dug up in the sandbank, high up the river Yealm, at a place where the water is nearly fresh. A great deal of sand has been removed from this sandbank during the last ten years, and it is now very muddy. This Nemertean, which was formerly rather common at this place, has since become quite rare. The other fragments, which also lack a head, were collected at the same place in 1898. After preservation the body is deeply furrowed and wrinkled, much as in *Cerebratulus corrugatus.* The anterior part of my specimen got very thin by preservation (breadth 5 mm.); the following region suddenly broadens till it has a breadth of 16 mm. The living specimen had a brownish colour, with more whitish margins. No markings were present.

The sections revealed some features which decided my classification of this species as a *Euborlasia;* I regard it, however, as a separate species from both *E. elisabethae* and *immaculata.*

The proboscis sheath is very short, as already in the thinner portion of the body it is devoid of its muscular coats. The intestinal caeca are richly developed and branched. The gonads are placed in rows between the caeca, alternating with their diverticula. They all open dorsally. Muscular septa are entirely absent. The intestinum with its diverticula and the gonads are surrounded by a thick layer of connective tissue, in which a great number of very narrow blood-vessels are imbedded. The structure of the epithelium agrees perfectly with Bürger's description; the large gland cells are especially conspicuous (Bürger. Monograph Naples, T. 22, Fig. 39).

SUB-FAMILY B. MICRURINAE.

Caudal cirrus present; proboscis sheath usually extends nearly or quite to the posterior end of the body.

GENUS **Micrura.**

Small, thin, mostly flattened and soft nemertines; head spathulate, ending bluntly, not separated from the body. Lateral margins of the body not remarkably thin; incapable of swimming. Often with a great many eyes. The mouth is circular. Proboscis sheath short.

1. **Micrura fasciolata** (*Ehrbg.*). (McIntosh. Monogr. Pl. VI, Fig. 2.)

Locality: Common in the dredgings from the Sound, Eddystone, Mewstone, and from the Rame-Eddystone Grounds.

General colour red or red-brown, head and ventral side white. 10–24 slender white transverse stripes across the dorsum. With 4–6 small eyes. Length 120–200 mm., breadth 1–2 mm.

Geographical distribution: Sweden, Great Britain, Northern coast of France, Mediterranean.

2. **Micrura aurantiaca** (*Grube*). (McIntosh. Monogr. Pl. VII, Fig. 4.)

Among some tubes of preserved nemertines I found one containing two nemertines from the Breakwater. They were supposed to belong to the same species, and must therefore have been very much alike in the living state. After preservation, however, the difference was very obvious, the one being rather flattened with lateral margins and the other being circular anteriorly and showing no margins even at the more flattened and weaker posterior part of the body. The colour of the more rounded nemertine was moreover brownish, while the bright yellowish colour of the flattened specimen at once proved it to be a small specimen of *Cerebratulus roseus*. So I suppose the colour of the other specimen to have been a very faint red or rose. The internal structure, however, makes it quite certain that this specimen must have been an abnormally faint coloured and rather large individual of *Micrura aurantiaca*. All traces of the original colour or of any markings had disappeared. Eyes are absent. The cutis is as thick as the epithelium. There are no traces of a connective tissue layer separating the cutis from the external longitudinal muscle layer, which is much thicker than the circular or inner longitudinal muscle layer. The latter layer has been very much reduced. The cerebral organs are placed above the lateral nerves. The dorsal part of the dorsal brain lobe is situated laterally to the ventral part; it ends anteriorly to the cerebral organs. The cephalic slits end where the cerebral canal originates from them. They reach as deep as the brain. The mouth is situated beneath the hinder end of the cerebral organs.

Geographical distribution: Both coasts of France and the Mediterranean.

3. **Micrura purpurea** (*Dalyell*). (McIntosh. Monogr. Pl. VII, Fig. 3.)

Locality: Rather common in dredgings from the Sound; occasionally a specimen from the Rame-Eddystone and the Mewstone Amphioxus Grounds.

Colour brown; head white, with a bright yellow transverse bar; eyes absent. Length 100–200 mm., breadth 2–3 mm.

Geographical distribution: Sweden, Great Britain, North coast of France, and Mediterranean.

4. **Micrura candida**, *Bürger* (= *Micrura lactea*, *Hubrecht*). (Joubin. Les Némertiens, T. 2, Fig. 23 bis.)

Locality: Two specimens from the Mewstone and two from the Mewstone Ledge.

Perfectly white. Eyes absent.

Geographical distribution: Channel and Mediterranean.

Two specimens are known from England, one from Stoke Point near Plymouth, and one from Halfway Rock.

GENUS **Cerebratulus.**

Body usually long and ribbon-like, much flattened, with very thin lateral margins; well adapted for swimming. Head pointed, lancet-like. Eyes are usually absent. Mouth mostly a long slit.

1. **Cerebratulus fuscus** (*McIntosh*). (McIntosh. Monogr. Pl. VI, Fig. 3.)

Locality: In dredgings from Asia Shoal, Queen's and New Grounds, Millbay Channel, and once from Mewstone Ledge.

General colour usually pale yellow, only pigmented on the head; sometimes, however, especially in bigger worms, a brown pigment was distributed all over the dorsum. Brain transparent. No eyes. Head spathulate, not separated from the body.

Geographical distribution: Sweden, Great Britain, France, Portugal, Mediterranean.

2. **Cerebratulus roseus** (*Chiaje*). (Bürger. Monogr. Taf. VI., Fig. 12.

Locality: Specimens were collected from the Breakwater, May, 1910; from Salcombe (Millbay) by Mr. Potts, in 1908; from the sand under Batten Castle, May, 1902; each time one complete specimen. A fourth specimen, collected from the Breakwater, was found in a tube of preserved specimens with *Micrura aurantiaca.*

The colour of the only living specimen I have seen was a dirty flesh colour; this individual was a female, which whilst being brought in broke into several pieces; however, no parts, not even the appendix, had been lost. The uncoloured margins were very conspicuous. The centre of the body probably took its darker colour from the eggs, which had an orange-brown tint and were partly deposited through the genital pores, situated in two rows on the dorsum. The mouth is large; the cephalic slits even reach the region of the mouth. The preserved specimens show the bright yellowish tint characteristic of *Cerebratulus roseus.* Bürger's figure moreover leaves no doubt as to the identity of my specimen with his *C. roseus.*

Geographical distribution: The French coast of the Channel and the Mediterranean.

3. **Cerebratulus alleni.** *Nov. spec.*

Locality: Yealm sandbank.

This Nemertine was collected on the 7th of November, 1907. The single specimen was given to me last summer. It had been preserved in corrosive sublimate and was then in alcohol. The only description I could get of the living animal was: colour, light flesh with white snout. It was supposed to belong to the same species as the individual described as *Micrura aurantiaca* and a small specimen of *Cerebratulus roseus.* From both, however, it differs in the shape of the head, which is conspicuously swollen at its hinder part and not separated from the body, so that it is best described as fig- or pear-like. The colour is a greyish brown anteriorly, which is replaced by a yellowish grey in the greater part of the body. These two colours are sharply separated from each other, just as in *Tubulanus polymorphus.* Sections revealed the following peculiarities, which made me create a new species for this single individual.

The cephalic slits are rather long, extending nearly to the beginning of the mouth, and farther than the cerebral organs themselves. They are not very deep, and reach only half-way to the brain. The cerebral pit, however, is deeper. The cerebral canal originates behind the dorsal brain lobe; this bifurcates into two lobes, the dorsal of which ends quite free in the longitudinal musculature in the region of the cerebral canal, separated from the ventral lobe by a thick band of tissue. The ventral lobe continues directly as the cerebral organ. This is never in contact with any blood-vessel, but lies internally to the circular muscle layer. The dorsal lobe of the dorsal brain, the cerebral organ, and the ventral brain lobe are situated above each other. The blood-vessels form one large dorsal anastomose in the head; the very short cephalic blood-vessels unite again within the brain; from this ventral anastomose an unpaired oesophageal blood-vessel takes its origin. This unpaired vessel divides into two in the region of the oesophageal nerve commissure. These two communicate often with the lateral blood-vessels situated on both sides of the proboscis sheath. In this region large gland cells are also conspicuous. They are buccal glands, which are enormously developed all round the mouth and the oesophagus. They are placed in clusters, and freely protrude into the blood-vessels, both into the lateral and into the oesophageal vessels, which frequently communicate with each other and form a network all round the oesophagus. They are even more richly developed than in *Micrura alaskensis, Coe;* they do not, however, extend outside the circular musculature.

The epithelium is not very thick. A separate cutis layer cannot be distinguished. The cutis glands are situated in the outer longitudinal muscle layer. A small layer of longitudinal muscle fibres, as thick as the epithelium itself, and traversed by the gland ducts, separates the layer of glands from the epithelium. These are themselves surrounded by muscle fibres, and do not form a compact layer. They are some two or three times as high as the epithelium. The bases of the cutis glands are situated not quite half-way between the outer bodywall and the circular muscle layer, laterally at a third of that distance only. The circular muscle layer is separated from the outer longitudinal by a thick nervous layer. Diagonal muscle fibres are absent. The circular muscle layer is rather feebly developed, and has twice the thickness of the epithelium, while the inner longitudinal muscle layer is twice to three times as thick as the circular layer in the oesophageal region. Longitudinal muscle fibres are not present between the oesophagus and prcboscis sheath.

The gonads alternate regularly with the intestinal caeca; the genital pores are situated above the proboscis sheath. In the intestinal region the outer longitudinal and circular muscle layers are very much reduced. This is especially the case with the outer longitudinal muscle fibres which form a layer of the same thickness as the cutis glands dorsally and ventrally, so that the latter reach the circular muscle layer; laterally, however, the layer of longitudinal fibres is thicker. The circular muscle layer is as thick as the epithelium, but the inner longitudinal muscle layer, which is five to six times as thick as the circular, has the same breadth as in the oesophageal region.

On the 1st of June part of a Nemertine was collected in dredging materials from the New Grounds. It turned out to be the posterior part of a very thin (1 mm.) nemertine, completely white, and long in comparison with the uniform breadth. The head failed, but an appendix was present. The structure of the body-wall reveals the characteristics of a Heteronemertean, as the outer longitudinal muscle layer is present. As with all the layers of the body-wall, this longitudinal muscle coat is very much reduced in size when compared with other nemertines. There are no traces of a cutis nor of any clusters of composite gland cells. Epithelium and outer longitudinal muscular coat have about the same breadth and are separated by the thin basement membrane only. The epithelial cells constitute a single layer. The circular and inner longitudinal muscle layers together have but one-third of the thickness of the outer muscular coat. They have about the same breadth. The longitudinal muscle fibres surround the wide enteron and the proboscis sheath, which ends just before the point where the tail is attached. The intestinal pouches are very shallow, and I have not been able to discern any septa. The gonads alternate with the intestinal pouches, or perhaps they are the cause of the appearance of these unreal diverticula. The position of the lateral nerve cords is the usual lateral situation. I have not been able to detect a median dorsal blood-vessel.

The point of greatest interest is the structure of the tail, which differs widely from any structure of this kind yet described. The epithelium has about the same height as in the body; many gland cells are present. I have not found any traces of the outer longitudinal muscle layer. Circular and inner longitudinal muscle coat are present as a single layer of muscle fibres. In the tail itself I have not been able to trace the nervous system; from the posterior commissure of the body, however, nervous tissue is seen to reach the basis of the tail. The centre of the tail is occupied by the intestine, which is seen to communicate widely with the intestine of the body and opens to the exterior by the anal aperture at the tip of the appendix. There are no intestinal pouches, nor gonads nor rhynchocoelom in the tail, which moreover lacks all connective tissue. Even the basement membrane could not be distinguished. If any nervous tissue is present it must be still epithelial.

As to the vascular system, I have not been able to find the anal anastomose nor anything like vessels in the appendix.

Certainly there can be no doubt that this specimen belongs to the sub-family Micrurinae. Had it not been for the tail, I should have felt inclined to identify the fragment as *Lineus niveus, Punnett*, which lives at the much greater depth of 100–140 m. near Bergen in Norway. As, however, Punnett describes the total absence of a tail in half a dozen specimens he collected, and as I can only judge their relationship by the hinder part of the body, I do not feel justified in considering them identical. If my supposition is right, I am inclined to think that a new genus ought to be created, on account of the structure of the appendix and the very primitive features which *Lineus niveus* reveals. The presence of an appendix certainly would approximate *Lineus niveus* still closer to *Zygeupolia* and *Micrella*.

ORDO II. ENOPLA.

The body-wall consists of a single-layered epithelium, a basal membrane, the outer circular and the inner longitudinal muscle layer. Mouth anterior to the brain, or the oesophagus opens into the rhynchodaeum. An oesophageal diverticulum is present. The nervous system is not situated in the body-wall, but in the central connective tissue.

SUBORDO A. PRORHYNCHOCOELOMIA.

Worms with a very long and slender body; they like to coil themselves up and to form knots. The proboscis is much shorter than the body. The proboscis sheath never extends into the posterior third part of the body, and exists usually in the anterior third only. Neurochords or neurochord cells fail.

I. FAM. EMPLECTONEMATIDAE.

Mostly very long and flat forms. Proboscis short and rather stout, with one very differently shaped central stylet only. Very often with many small eyes; seldom two or four eyes. No statocysts.

GENUS **Emplectonema.**

Very long and slender. Alimentary tract and proboscis open together. Cerebral organs very small, generally situated a long distance in front of the brain. Mostly with many small eyes. The proboscis sheath does not quite extend to the second third of the body. Sexes separate.

1. **Emplectonema gracile** (*Johnst.*). (McIntosh. Monogr., Pl. II, Fig. 5.)

Locality: In dredgings from the Mewstone; between tidemarks at Breakwater, Drake's Island, Cawsand Bay. Far less common than the next species.

The colour of this Nemertean is usually a more greyish green than the figure in McIntosh's monograph indicates; ventral surface white. The head is lined with white and possesses a faint yellow transverse bar. It is broader than the body, but not sharply separated. Cerebral organs a long distance in front of the brain. 20–30 eyes in two groups at both sides of the head. The handle of the central stylet is twice the length of the stylet itself; all stylets are curved. With two pouches each containing 5–6 accessory stylets. Length 20 cm. or more, breadth 1 mm.

Geographical distribution: This species is widely distributed. It is known to occur on the West coast of North America as well as in Chile and the Aleutian Islands, the coasts of France and Germany, Madeira and the Mediterranean.

2. **Emplectonema neesi** (*Oerst*). (McIntosh. Monogr. Pl. III, Fig. 6; and Joubin, Les Némertiens, Pl. III, Figs. 77–80.)

Locality: Common between tidemarks in the Sound; from Breakwater and the Mewstone; occasionally met with in dredgings at a depth of 10–15 fathoms.

This Nemertean is much more abundant than *E. gracile*. However, it is not so widely distributed. *E. neesi* has been recorded only from the Atlantic coasts of Europe. It ranges from Iceland to the Channel.

Head broadened and of a yellowish colour, paler than the body. The dorsum has a brown hue in which flesh-coloured stripes occur;

sometimes these stripes are broken up into patches, which give the animal a speckled appearance. The ventral surface is white. Cerebral organs at a great distance in front of the brain. Numerous small eyes arranged in four clusters. The oesophageal diverticulum sends two pouches to the brain. Both the central stylet and its basis are short and stout; they are of the same length. Two pouches, each with three accessory stylets. Length to 46 cm., breadth ½ cm.

3. **Emplectonema echinoderma** (*Mar.*). (Bürger. Monogr. T. II, Fig. 3.)

Locality: One specimen from Millbay Pit.

Bürger's figure gives a very good idea of the Plymouth specimen; the head shows the same form and markings. The colour is generally a more orange-red. A number of very small eyes, arranged in a row, are situated on the margins of the head; they do not show very much, which is probably due to the want of clearness of the tissues of the head, and they certainly were not so numerous as those described by Bürger. The transparent hooks are quite characteristic. Length 120 mm., breadth 1½–2 mm.

Geographical distribution: Mediterranean, Madeira, and Plymouth.

GENUS **Carcinonemertes.**

Head without distinct lateral grooves, not demarcated from the body. Ocelli 2. Mouth and proboscis open together; oesophagus extremely short, opening broadly into the intestine through a large muscular chamber. Proboscis but little developed, very small in size and extremely short, without lateral pouches of reserve stylets, but armed with a central stylet and basis only.

1. **Carcinonemertes carcinophila** (*Köll*). (Joubin. Les Némertiens, Pl. III, Fig. 81. McIntosh. Monogr. Pl. I, Fig. 5.)

This parasitic Nemertean lives in self-secreted tubes between the egg masses of *Carcinus maenas* and *Portunus depurator.* Only two out of a great number of *Carcini* I examined were inhabited by this worm; one specimen in each. On *Portunus*, however, it was more common, especially in specimens from dredgings. If the crabs had been collected on shore I never found them inhabited by this parasite. The tube, in which the orange or pale reddish animal folds itself together, is attached to the axis of the feet that bear the eggs. I have not been able to find any nemertine on the gills either of *Portunus* or of *Carcinus* or *Galathea.*

This species was with certainty known only to occur on *Carcinus maenas;* probably *Galathea strigosa* and *Xantho floridus* may also be infected with them. In New England they live on *Platyonychus ocellatus.*

Geographical distribution: *C. carcinophila* has not been found previously in England; it has been recorded from the Atlantic coasts of Belgium and France, from the Mediterranean and from New England.

GENUS **Nemertopsis.**

As *Emplectonema*, but instead of many, only four eyes, situated in a rectangle. The distance between the eyes of one pair is smaller than that between the eyes of one side.

1. **Nemertopsis flavida** (*McIntosh*), *Beaumont.* (McIntosh. Monogr. Pl. IV, Fig. 1; and Joubin, Les Némertiens, Pl. II, Fig. 61.)

Locality: Common in the Sound, both from dredgings and between tidemarks. Once from a dredging near the Mewstone.

Under this name I unite both the *Nemertopsis* species, described by Beaumont (1900, p. 817 and 818). It seems to me very doubtful whether *N. tenuis* must be distinguished from *N. flavida.* The only difference between the two so-called species is to be found in the colour, which is quite white in *N. flavida* and a very faint pink in *N. tenuis.* This, however, might be due to the colour of the blood, which is decidedly red in the last species and cannot be seen in the first. Moreover, the colour of *Tetrastemma flavida, McIntosh*, is pinkish or pale peach, which agrees with *Nemertopsis tenuis,* not with *N. flavida.* Beaumont states a difference in the extension of the proboscis sheath. This I have not been able to ascertain. A difference in body length of the animals might have caused this just as well, especially as the worms very easily break into pieces. No other difference between *N. flavida* and *tenuis* has been described. As to the value of the red-blood colour, this is not a character on which alone to base a new species. As long as no other difference between these two forms is known, we cannot regard them as separate species. Perhaps they are only varieties of one species, but even this seems questionable to me.

Moreover, Beaumont does not seem to be quite certain himself as to the value of his distinction. "The doubtful status of *Nemertopsis tenuis* as a species distinct from *N. flavida,* and the fact that they have rarely been distinguished with certainty, make it expedient to consider them together (W. I. B.)." (Plymouth Marine Invertebrate Fauna, 1904. Nemertea.)

In this case the name *Nemertopsis tenuis, Bürger*, has to be dropped; it must be replaced by *Nemertopsis flavida* (*McIntosh*), *Beaumont*, which species is not to be regarded as synonymous with *Tetrastemma flavida*, *Bürger*.

Head attenuated; reddish or pale pink to white. With four minute eyes. The very small cerebral organs are situated in front of the brain. The central stylet and its base have nearly the same length. All stylets are slender. With two accessory pouches, containing each three accessory stylets. Length 4–5 cm., breadth ½ mm.

Geographical distribution: Mediterranean, Channel coasts, Scotland.

SUBORDO B. HOLORHYNCHOCOELOMIA, Bürger.

Body usually short and stout; most species do not show any tendency to coil themselves up. Proboscis at least as long as the body. The proboscis sheath ends usually just in front of the anal aperture, and always extends into the last third part of the body.

I. FAM. AMPHIPORIDAE.

Worms of a length of some centimetres, even of 10 cm. sometimes; the smaller species are very stout, and the larger are rather stout too. The gonads do not alternate with the intestinal diverticula. They bifurcate. The oesophageal diverticulum sends long pouches to the brain. Proboscis sheath without lateral diverticula. Proboscis with one central stylet and conical handle. Cerebral organs large. Nearly always with many large eyes. Number of proboscis nerves variable.

GENUS **Amphiporus**.

Extremely contractile; in contraction the head is invisible as a rule. They cannot swim. Usually numerous eyes, sometimes failing, never four. One central stylet, but often many pouches, each containing a few accessory stylets. The handle is always conical. Mouth and proboscis pore join together. Proboscis sheath without pouches. Sexes separate.

1. **Amphiporus lactifloreus,** *McIntosh*. (McIntosh. Monogr. Pl. I, Fig. 1).

Locality: In shallow water, near the coast, and between tidemarks. From all dredging grounds in the Sound, and once from a dredging at the Mewstone Ledge (18–27 metres).

A flattened, very soft nemertine of a pale pink or white colour. The head is not sharply separated from the body. Cerebral organs in front of the brain. A number of small eyes present on the head; they are arranged in two groups on each side, "the posterior group generally forming a triangle, with one eye-speck (that most remote from the snout) much larger than the rest."

Geographical distribution: North Atlantic and Mediterranean coasts.

2. **Amphiporus dissimulans**, *Riches*. (Joubin. Les Némertiens, Pl. III, Fig. 42, and p. 129, Fig. 16.)

Locality: Dredged from all grounds in the Sound and near the Mewstone.

Length 5 cm. The colour is variable, most frequently a very pale pink. Head broadly spathulate, pointed, sharply separated from the body. The eyes are never divided into groups and are very numerous. Cephalic grooves as in Joubin's *A. roseus*. Tail oar-like.

I should not be surprised if the anatomy of the specimens described by Riches and Beaumont under the above-cited names proved them to belong to the same species, in this case *A. lactifloreus*.

As far as the internal structure is known every evidence of a difference fails. "The shape of the head and of the tail, the number and arrangement of the eyes, the position of the cephalic grooves, and the difference of habitat, *A. lactifloreus* being a shallow-water form, and these specimens being never obtained in less than 15 fathoms, are the distinguishing characters," says Riches.

As to the difference of habitat I cannot agree with Riches. Both *A. dissimulans* and *A. lactifloreus* have been recorded in dredgings from the same spot, as Asia Shoal, Queen's Grounds, Millbay Channel; moreover, *A. lactifloreus* proves not to be a shallow-water form alone, as I got quite a typical specimen from the Mewstone Ledge, at a depth of 10–15 fathoms; *A. dissimulans*, on the contrary, has been collected at Drake's Island between tidemarks (I cite from the Invertebrate list). But even if a difference in habitat exists, as Riches supposes, the distinguishing characters might be due simply to this. Certainly it is remarkable that both species are distributed alike in the neighbourhood of Plymouth. If *A. dissimulans* occurs in the deeper parts of the Sound, *A. lactifloreus* occupies the shores of the same parts (according to Riches). On the Mewstone it is the same; in shallow water *A. lactifloreus*, from the Mewstone Ledge *A. dissimulans*. To these spots both species seem to be confined.

As a distinguishing character the arrangement of the eyes does not hold good either. I met with several specimens of so-called *A. dissimulans*, the eyes of which were arranged in two groups as in *A. lactifloreus*. Other specimens had the *lactifloreus* habitus, but the eyes formed a continuous series on each side of the head. The characters of habitus and arrangement of eyes proved to be quite insufficient to distinguish between the two species. As to the only remaining character, the position of the cephalic grooves, I can only agree with

Beaumont, that their arrangement in *A. lactifloreus* is very similar to that in *A. dissimulans* (1895, p. 360). In fact, I have not been able to see the slightest difference between them; in both species the cephalic furrows are arranged as described by Beaumont.

All distinguishing characters given by Riches between *A. lactifloreus* and *A. dissimulans* fail. The varieties as described by him and by Beaumont certainly exist, but they are connected by a series of variations of their characters, which makes it very probable that they themselves are to be looked upon as varieties of one single species, in this case *Amphiporus lactifloreus.*

3. **Amphiporus allucens** (*Bürg.*). (Bürger. Monogr. Pl. IV, Fig. 35).

Locality: One specimen from the Mewstone Ledge (10–15 fathoms) and one from the Rame-Eddystone Grounds.

The specimens recorded by me under this name fully resemble *A. pulcher var. allucens, Bürger.* Colour bright salmon, as in *A. pulcher* described by Beaumont; the head is more yellow, with the central nervous system showing through as a pale pink-coloured spot. Head not separated from the body. The eyes are large and black and were arranged in a double continuous row on each side of the head. The last eye of the shorter row is larger and lies just in front of the brain. The cephalic grooves join ventrally in front of the brain. The absence of secondary cephalic grooves and of a reserve central stylet decided me to separate this species from *A. pulcher, Bürger.* As to its relations to *A. pulcher, McIntosh*, the number and arrangement of the eyes, the shape of the head and the whole habitus of the worm are so different, that it seems impossible to confuse them.

Geographical distribution: Naples.

II. Fam. DREPANOPHORIDAE.

Genus **Drepanophorus.**

Broad and ventrally flattened worms of some centimetres length. Intestinal diverticula not bifurcated; the oesophageal diverticulum sends pouches in the direction of the brain. Gonads alternating regularly with the intestinal diverticula. Numerous eyes. Cerebral organs at the sides of or posterior to the brain. Proboscis sheath with metamerically arranged lateral pouches. Proboscis with many central stylets, situated on one crescent-shaped handle.

1. **Drepanophorus spectabilis** (*Quatr.*). (Bürger. Monogr., Taf. III, Figs. 28 and 28A.)

Locality: Queen's and New Grounds (5–6 fath.) and Mewstone Ledge (10–15 fath.).

The colour is yellowish pink, interrupted on the dorsal surface by six longitudinal brown stripes; the outer lines are confined to the body; they cease just before the cephalic furrows. On the head, which is narrower than the body and well separated, four dorsal stripes continue. Many eyes are present, arranged centrally in two rows on each side. The cephalic grooves are conspicuously branched and show a brown pigment on the transverse ridges.

Geographical distribution: Plymouth is the most Northern habitat of this species; it has not been recorded for any other place in England. *D. spectabilis* occurs on the Atlantic coasts of France and at the Cape Verde Islands as well as in the Mediterranean.

III. Fam. PROSTOMATIDAE.

Usually short and slender, somewhat flattened Nemertines with four eyes. Gonads alternating with the intestinal diverticula which are not bifurcated. The oesophageal diverticulum has no pouches. Cerebral organs anterior to the brain. Proboscis with ten nerves.

Genus **Prostoma.**

Usually nearly cylindrical, ventrally somewhat flattened, soft worms. Head sometimes sharply, often however slightly or not at all separated from the body; spathulate or rounded, and often somewhat broader. Nearly always the head shows a characteristic pigmentation. Proboscis with ten nerves. The central stylet and its handle are of equal length; in the middle the base is narrowed. Only two stylet sacs, containing two to three accessory stylets each. Cerebral organs situated in front of the brain.

1. **Prostoma melanocephalum** (*Johnston*). (McIntosh. Monogr. T. 2, Fig. 1.)

Locality: In dredgings from Queen's Grounds and between stones from the Cattewater.

This species can be distinguished easily from all other Prostomas by the large, intense black spot on the head; this and the yellow colour of the body, in which no traces of brown are to be seen, make it quite impossible to confuse them with *P. coronatum*, as Beaumont and Riches have done. Moreover, a great difference in habitus exists between both forms, mature specimens of *melanocephalum* having a length of 30–60 mm. with a breadth of 2 or 2½ mm., while *coronatum* is one of the slender species of this genus.

P. melanocephalum is a shallow-water form, not at all common near

Plymouth. I got it twice from Queen's Grounds, once from the Cattewater, on each occasion a few specimens.

Geographical distribution: Sweden, the Atlantic coasts of England, France and Madeira, the Mediterranean and the Pontic coasts.

2. **Prostoma coronatum** (*Quatr.*). (Bürger. Monogr. T. 3, Figs. 2, 8.)

Locality: Fairly common in all dredgings from the Sound; Mewstone and Cattewater; once between tidemarks at Rum Bay.

To this species must be referred the greater part of the nemertines described by Riches as *Tetrastemma melanocephalum*. *P. coronatum* never attains the size of *P. melanocephalum*, its average length being 12 mm. with a breadth of 0·5–1 mm. (even in sexually mature specimens). The shape of the *brown* pigment on the head, as indicated in Bürger's figure, is quite characteristic. It is the same as in *P. diadema, Joubin* (Les Némertiens, Pl. III, Fig. 66).

Geographical distribution: The Atlantic coasts of Norway and France and the Mediterranean are known as its habitat.

3. **Prostoma vermiculus** (*Quatr.*). (Joubin. Les Némertiens, Pl. III, Fig. 64.)

Locality: Rather common in dredgings from Asia Shoal; from some other dredging grounds in the Sound, near the Mewstone and Mewstone Ledge, and once between tidemarks at Rum Bay.

Joubin's figure gives by far the best idea of this species. However, the individual reproduced is a small one, as ripe specimens of *vermiculus* are very large in comparison with *P. coronatum*. They have the same size as *P. melanocephalum* and can be distinguished readily from both *coronatum* and *melanocephalum* by the shape and the colour of the pigment spots, constituting a pair of longitudinal brown stripes, connecting the eyes.

Geographical distribution: *P. vermiculus* has been recorded from several spots on the English coasts, and is distributed all over the Northern part of the Atlantic, from North America to Norway and Madeira and the Mediterranean.

4. **Prostoma peltatum** (*Bürger*). (Bürger. Monogr. Taf. III, Fig. 6.)

Locality: Two specimens from the Bridge.

This species is characterised by the presence of two pairs of eyes, of which the anterior pair is at least twice as large as the posterior. A transverse band of brown pigment is situated between the eyes; it does not hide them. Colour deer-brown. Both specimens were ♀. Length 40–50 mm., breadth 2 mm.

Geographical distribution: Naples.

5. **Prostoma longissimum** (*Bürg.*). (Bürger. Monogr. Taf. III, Fig. 15.)

Locality: One specimen in a dredging from the Mewstone.

The single individual which I describe under this name is identified only with hesitation with the Neapolitan species. The description Bürger gives in his Monograph agrees completely with the external features of my specimen, and so does the figure cited. The most striking characteristic is the transverse bar of bright red pigment on the head. However, a great difference of habitat exists between the Mediterranean and English forms, the latter living at a depth of 10 fathoms at least, the Naples specimens being very common on the beach together with *Emplectonema gracile.*

Geographical distribution: Naples.

6. **Prostoma robertianae** (*McIntosh*). (McIntosh. Monogr. Pl. III, Fig. 1, and p. 167, text Fig. 8.)

Locality: Rame-Eddystone.

Head separated from the body by a brown pigment ring, from which a pair of longitudinal brown stripes proceed towards the tail. A median white line is also present on the dorsum. Colour brownish pink. The anterior pair of eyes is decidedly larger than the posterior pair, which was not covered by the brown collar. Length 8 mm., breadth ½ mm.

This rather characteristic Nemertean seems to live at a greater depth than most of its relatives. McIntosh describes it from the Hebrides and the Shetland Islands at a depth of 6–8 fathoms; Beaumont from the Isle of Man at 15 fathoms, and from Valencinia Harbour at 1–2 fathoms; Bergendal from Kristineberg at 15–20 fathoms; while the Plymouth specimen lived at a depth of 25–30 fathoms.

7. **Prostoma candidum** (*Müller*). (Bürger. Monogr. T. III, Figs. 13 and 19.)

Locality: Asia Shoal and Queen's Grounds.

A few specimens of this Nemertine were met with in dredgings from Asia Shoal and Queen's Grounds. A characteristic brown pigment is present at the cephalic grooves. The colour of my specimens was not as green as in Bürger's figure; it agreed better with that of McIntosh's figure, in which, however, the cephalic grooves have not been represented. These cephalic grooves, the shape of the head and the bright yellow colour distinguish *P. candidum* (*Müll.*) from the next species, to which probably the majority of *P. candidum*, *Riches*, belongs. He describes, however, a specimen from Redding Point which seems to be identical with *Prostoma candidum* (*Müll.*). Length 12 mm., breadth ½ mm.

Geographical distribution: All coasts of the Northern part of the Atlantic, including the Channel, the North Sea and the Baltic, North America, Madeira, and the Mediterranean.

8. **Prostoma flavidum** (*Ehrbg.*). (Bürger. Monogr. Taf. III, Fig. 20.)

Locality: From Queen's and New Grounds, Cattewater and Rame-Eddystone in dredgings; between tidemarks at Rum Bay.

This species includes one of the most common Nemerteans of Plymouth Sound. The colour is a pale yellow or reddish tint, which may even be quite pink, as in a specimen dredged from the Rame-Eddystone Grounds. It can be distinguished from *P. candidum* by the colour and by the total absence of any pigment on the head. The reddish and yellow variety of *P. candidum*, *Riches*, probably belongs to this species, which is *not* synonymous with *T. flavidum* of McIntosh, Riches, and Beaumont. Length 12 mm., breadth ½–1 mm.

Geographical distribution: Sweden, Belgium, coasts of France, Madeira, Mediterranean, and Red Sea.

9. **Prostoma cephalophorum** (*Bürg.*). (Bürger. Monogr. Taf. III, Fig. 22.)

Locality: A few Nemertines belonging to this species have been found in dredgings from New Grounds and the Bridge, Asia Shoal, and Queen's Grounds.

Head rhomboid, broader than the body, sharply separated from it, with four rather large eyes. No markings. The general colour is brown; the head and the margins of the body, however, are less darkly coloured. My specimens agree fully with the description given by Beaumont (1900).

Geographical distribution: Ireland, Isle of Man, coast of Cornwall and Naples.

10. **Prostoma ambiguum**, *Riches.*

Locality: Common at all dredging and trawling grounds in the Sound, in the neighbourhood of the Mewstone, and on the Rame-Eddystone Grounds, at a depth of 25–30 fathoms.

My specimens perfectly resemble those described by Riches. Length 10–15 mm., breadth 1 mm. Four brown eyes, the anterior pair of which is at least twice as large as the posterior. Colour pale yellow, with a reddish brown pigment developed on the dorsum. Head broadened and separated from the body.

Geographical distribution: Plymouth.

11. **Prostoma helvolum** (*Bürg.*). (Bürger. Monogr. Taf. III, Fig. 16.)

Locality: Mewstone Ledge and Rame-Eddystone Grounds. Depth 10-30 fathoms.

This yellow Nemertine reminds one very much of *Prostoma candidum;* it is very slender, however, attaining a length of nearly 2 cm., at a breadth of less than 1 mm. This, the presence of a shining white glandular area on the tip of the head in which the anterior pair of eyes is situated, and of a similar very conspicuous glandular spot in the anal region, characterize *P. helvolum.*

Geographical distribution: Naples.

12. **Prostoma quatrefagesi,** *Bürg.*

Locality: One specimen from New Grounds.

This species has no external markings. The colour is a bright yellow and the animal was quite transparent. On account of these characteristics it reminds one very much of *P. candidum.* However, the proboscis sheath does not extend into the posterior third part of the body. Moreover the number of the stylet sacs is quite unique amongst English *Prostoma's.* Four pouches, containing at least twelve accessory stylets, are present.

Geographical distribution: Sicily and Naples.

13. **Prostoma herouardi,** *Oxner.* (Bull. Inst. Océanogr. Monaco, 1908, No. 127. Pl. I, Fig. 1.)

Locality: From hulks in Plymouth Sound.

Once I got quite a number of these Nemertines from between Laminaria roots. Their length did not exceed 5 mm. and they certainly were not broader than $\frac{3}{4}$ mm. The colour is a light flesh colour, with a dark wine-red stripe on the dorsal surface, which extends from the tip of the head to the end of the tail. Four eyes, arranged so as to form a trapezium if the head is contracted, are situated in front of the brain. Cephalic grooves are not present on the dorsal surface of the head. The cerebral organs, however, are in front of the brain and are funnel-shaped. The proboscis sheath continues to the end of the body; proboscis with two stylet pouches, each containing two reserve stylets. Central stylets as long as the handle, which is not narrowed in the middle. The median dorsal red stripe is due to epithelial pigment.

Geographical distribution: Roscoff en Finistère.

GENUS **Oerstedia.**

Body cylindrical; head perfectly continuous with the body. Four small eyes.

1. **Oerstedia dorsalis** (*Abildg.*). (Bürger. Monogr. Pl. III, Figs. 30 and 36.)

Locality: Abundant everywhere in Plymouth Sound; Rame-Eddystone Grounds, and between weeds in Whitsand Bay.

I found several varieties of the species in dredgings; of these *O. dorsalis var. marmorata* was the most common; I found it everywhere in Plymouth Sound, at Whitsand Bay and in the Rame-Eddystone dredgings. From the last spot, however, I several times collected the variety *viridis* (Bürger, Monogr., Pl. III, Figs. 34 and 34a), and on one occasion a single specimen of var. *cincta* (Bürger, Monogr., Pl. III, Fig. 27).

Geographical distribution: Atlantic Ocean, with the Baltic, North Sea, the Channel and the Mediterranean.

UTRECHT, September, 1911.

On a Method of Rearing Larvae of Polyzoa.

By

Dr. M. Hasper, Darmstadt.

COLONIES of *Bowerbankia pustulosa*, collected in July and August, 1911, in and near Plymouth Sound, contained a great many ovicells and produced numerous larvae, when kept in a flat glass trough and put under circulation during the night. The small yellowish larvae have a decidedly positive phototropism. They gather on the surface of the water on that side which is turned towards the light, from which position they sink to the bottom of the glass. Their movements slacken gradually in the course of a few hours, and at last are limited to revolving in a small circle until they fasten on the sides of the glass. Here they complete their metamorphosis, and in a few days the primary polypides are expanding their ciliated tentacles. The result was better when the just-hatched larvae were brought into a jar sterilised by hot water and filled with so-called outside water, i.e. water from beyond the Breakwater. This jar was fitted with a glass stand carrying a number of cover-glasses. When the larvae settled on these, it was easy to make total preparations of them without detaching them.

But this method is not sufficient when sections of a just-settled larva or a young primary zooecium are to be made without injuring it by its separation from the substratum. In this case the larvae must be induced to fasten to a material which can easily be cut with the object. For this purpose egg-shells proved useful. They were washed with water, then kept in alcohol of 70 per cent. for about a day, and the coagulated albumen was mechanically removed. The alcohol was afterwards extracted by sea-water. Prepared in this way, the egg-shells were filled with outside water, charged with a number of swimming larvae and kept cool by running water underneath an inverted bell-glass. As long as the larvae were still active, the water was renewed with a pipette twice a day. When the metamorphosis was accomplished and the young polypide began to come out of its cell, it was necessary to add some well-adapted food. I made use of two cultures of algae in sterilised water, kept in stock in the laboratory and kindly placed at my disposal: *Pleurococcus mucosus* and *Nitzschia* *closterium forma minuta.* In other cases the egg-shells were put into a larger jar fed with water from the tanks by means of a siphon.

When the animals are in the stage required, they can be fixed in a very simple manner. To the younger stages the fixing fluid was added directly after having poured out the water. If the individuals were further developed and were to be fixed with expanded polypides, they were paralysed by some crystals of menthol floating upon the surface of the water for some six hours and killed by a pipetteful of the fixative, squirted out directly upon them in order to prevent them from collapsing when the water was removed. As most of the fixatives contain some percentages of acid more or less, the innermost layer of the calcareous shell is dissolved and so the inner skin is spontaneously detached. When a mixture of a hundred parts of a saturated solution of corrosive sublimate and five parts of glacial acetic acid was used, the inner skin was lifted up by bubbles of carbonic acid in a few minutes, so that it is easy to detach the membrane after having washed the objects in the shells, and cut the latter into small pieces. The pieces of membrane with the attached polypides are then treated in the usual way. The membrane becomes very transparent in xylol or cedarwood oil, and the object cannot be lost in the paraffin. The egg-skin serves as a means of orienting the object too, and can be sectionised so excellently that it is not in the slightest degree an impediment.

I employed this method for the larvae of several species of Polyzoa and a Tunicate of the family of Didemnidae. It is especially useful, of course, when the larvae are of a dark colour, as, for instance, those of *Bugula neritina* Oken (= *Cellularia neritina* Pallas), which contrast with the white ground most excellently. These larvae settle in numbers just below the edge, or even on the free surface of the water taking advantage of the surface-tension.

An Account of the Natural History of the Slipper-Limpet

(*Crepidula fornicata*),

With some remarks on its occurrence on the Oyster Grounds on the Essex Coast.*

By

J. H. Orton, B.Sc.

THE American limpet, or slipper-limpet, known to naturalists as *Crepidula fornicata*, was introduced into England about 1880, being recorded at that time by Mr. B. S. Dodd in the Proceedings of the Malacological Society for 1893. Dodd, it is interesting to note, sounded even at that early time a warning note against the possible spread of this animal, and the probability of its becoming an enemy to the oyster farmer. There is no doubt that this limpet has been, and is probably still being introduced along with American oysters, on which it fixes itself. I have myself seen it unshipped along with oysters, but all the specimens I found had died recently. The spread of the limpet appears to have been very rapid on some grounds, as, for example, at West Mersea, where, since its appearance about eight years ago (from information obtained from local oyster fishermen), it has spread so that it is now more common than oysters.

The rapid spread of Crepidula on this coast is probably due chiefly to the abundance of the kind of food which the animal likes, and I am able to show that Crepidula feeds on exactly the same food as oysters. Thus the suitability of the Essex coast for the culture of oysters rendered it equally suitable for the spread of Crepidula. The mode of feeding of Crepidula is the same in principle as that of the oyster. Water is drawn in and expelled at the front end of the shell; the ingoing current entering on the left side, passing over the back of the animal, and out at the right side, as indicated in the accompanying diagrams (see† page 447, Figs. 1 and 2). Between the ingoing and outgoing currents the gill of the animal acts as a strainer, which collects all the food material that occurs floating in the water. The collected food material is washed towards the mouth in two main batches, according to whether it is coarse or fine. The coarse particles on being drawn in with the water can be seen to be washed forwards along the left side of the animal towards a pouch which hangs down in front of the mouth. (See Figs. 1 and 2 A.) In this pouch the particles collect, and Crepidula can feed when it wants. The greater part of the fine particles, however, are treated differently. These, on being drawn against the gills, are washed towards the tips of the gills, which just roof in a deep groove on the right side of the animal. (See Fig. 1 B and Fig. 2 B.) In this groove the fine particles are collected, and every now and then are shot forward towards the mouth in a cylindrical mass. (See Fig. 1 B.) As the food mass passes forward, the animal seizes it in its mouth and eats it. I have fed Crepidula on diatoms, and watched it feeding in this way, and if very fine coloured particles be added to the water, a coloured cylindrical mass may be seen collecting on the right side of the animal just behind the "head," and the action of swallowing easily observed. Examination of the gut contents of Crepidula and the oyster shows that the same kinds of diatom are found in both animals, and moreover, that the commonest diatoms are the same in both animals. The fæces of slipper-limpets fed on a culture of diatoms consist wholly of diatom shells embedded in mucus. Thus it will be seen that Crepidula can be fed on diatoms. A chain of six individuals lived for nine months in a large-sized jam jar which contained sterilised water, to which supplies of diatoms and other small organisms were added at intervals. At present there are in our tanks a large number of living chains which have already been there nearly a year, and several other chains which I have had about seventeen months. These are all undoubtedly feeding on the floating substances in the tanks. A more detailed account of Crepidula's mode of feeding and of the gut contents of Crepidulae and oysters will be published shortly in the Journal of the Marine Biological Association.

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* Printed by the Kent and Essex Sea Fisheries Committee, January, 1912, for distribution amongst the Committee.

† These figures are incorporated in another and fuller account of the mode of feeding of Crepidula (see pp. 444–78 of this number) which was written subsequently to the printing of this Report.

In accounting for the spread of Crepidula in its new environment, some allowance must also be made for the probable absence of some of the enemies which it had in its original home, and also for the probability of an invigorating effect of the new environment. With regard to this latter suggestion may be noted the apparently early spawning of English Crepidulae. I am informed by Prof. Conklin that American Crepidulae begin to spawn in May and possibly in April, while English Crepidulae begin to spawn in early March.*

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* Since this Report was written, Crepidula spawned in the tanks at Plymouth in early February.

The direct factor in the spread of Crepidula, however, lies in connection with the spawning habits, as may be gathered from what follows. Crepidula spawns during the period from early March to the beginning of November, but the greater number of individuals appear to spawn about May. This limpet takes special care of its spawn. It constructs about 50 to 60 membranous bags, into each of which it passes about 250 eggs, and as the bags are made and filled with eggs they are closed and fastened together by short cords. These cords are finally all stuck on to the surface on which the slipper-limpet happens to be sitting, so that when by taking away the spawning individual the spawn is uncovered, it looks like a bundle of balloons, each containing a number of eggs. Each spawning individual, therefore, lays about 13,000 eggs, which are carefully protected beneath the shell of the mother until they are hatched. It is unlikely that individuals would spawn more than once a year, but beyond the fact that May seems to be a maximum spawning period, I have as yet no definite information to offer.

* To return to the fate of the eggs of Crepidula after they are laid: the eggs are protected by the mother Crepidula for about a month, but about the end of the month holes appear in the egg-bags, and the developing Crepidulae escape by swimming away from their parent. At this stage the Crepidulae resemble tiny shore sea-snails (*Littorina*), having, however, a transparent shell. In this condition they swim about at the surface of the sea, according to Prof. Conklin, for about two weeks. Towards the end of that time the young limpets begin to seek the bottom, and soon afterwards slipper-limpet spat having the typical flat shell may be found on the various objects on the sea-bottom. Thus young Crepidulae develop from the egg in about six or seven weeks.†

* The rapid spread of Crepidula along the Essex coast is now seen to be easily possible, for young swimming forms could easily have been carried by currents to the various parts of the coast, where they have settled down and formed new centres for a wider distribution. It will be an interesting problem to observe how far this species will spread in the future.

Besides the remarkable rate at which Crepidula is over-running the oyster beds, the species presents another feature which the oyster dredgers find very troublesome, namely, the curious habit of sticking together in long chains by one individual sitting on the back of another. These chains are without doubt permanent collections of individuals, as can be seen from the following facts:—

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* These paragraphs were inadvertently omitted from the original Report.

† The information given of the development of Crepidula has been drawn largely from Prof. Conklin's work on Crepidula (see *Journal of Morphology*, Vol. XIII, pp. 17, 18). By observations similar to his I judge also that the period of development from egg to spat is about six or seven weeks. More definite information, however, is to be desired on this point.

(1) The accurate fitting of the edge of the shell of each animal into the crevices and irregularities of the surface or shell upon which it is seated; hence, only short periods of separation could be possible. Thus the animal has, so to speak, grown in the position.

(2) In cases where a chain is attached to soft rock, the proximal individuals wear in the rock itself a deep impression of the edge of the shell by a lateral movement, probably executed in the search for food. In this way the animal becomes seated on a boss of the rock with a pit all around it.

(3) Experiments on separating the members of chains, and giving the animals an opportunity of re-chaining, indicate that the older animals can only re-attach themselves to anything with difficulty, but attach themselves most easily to a smooth surface. If a number of such animals be left in a dish, they make no attempt to re-chain in their previous order, and indeed large specimens appear unable to move about, or move only with great difficulty.

By supporting dismembered individuals of a chain in the same relative positions which they occupied before being separated, I have succeeded in re-forming a number of chains, but in order to effect this it is necessary to place the animals close together, and to keep a close watch on them, so as to replace them should they fall out of position. In many cases, however, even with such care, the animals are apparently unable to re-attach themselves.

(4) Prof. Conklin states that old individuals sometimes become permanently fixed by a calcareous secretion of the foot, and recently I have observed several old individuals which appeared to be just beginning to form such a calcareous attachment.

(5) I have kept a number of chains of Crepidula alive for as long a period as a year without the members of a chain separating, except in one or two cases, which may thus be regarded without doubt as exceptional.

Thus there would appear to be no doubt that the chains are permanent. The chains, however, are composed of almost entirely middle-aged or elderly Crepidulas, so to speak. But the very young ones are motile, and move about from place to place. I have shown elsewhere that Crepidula is a protandric hermaphrodite, that is to say, that all the individuals are born as males, and, passing through an apparently hermaphrodite stage, change into females. Consequently, chains are formed in the following manner:—

The young male individuals creep about from place to place, and eventually settle down either on shell or some similar surface, or on the end of a chain. Suppose an individual to settle on an oyster shell. The young male grows larger, and at the same time the edge of its shell takes on the contour of the surface to which it is attached, so that they fit accurately together. As the individual increases in age, it begins to change into a female, but meanwhile another young male may creep on to its back and settle down. This latter individual in turn begins to change into a female, another young male in the meantime having crept on to its back. With a repetition of this process, longer and longer chains are formed, until in odd cases as many as thirteen individuals may be found in chain. In this way it will be seen that in any chain the bottom individuals will be females, and the end individuals males, while between these may occur individuals of all intermediate sex forms between male and female.

Regarding, therefore, the fact established that Crepidula is protandric, the occurrence of a graded series of sex forms from the outer to the attached ends of the chains is further evidence that the chains are permanent.

With regard to the age of chains, I have not yet finished my investigations, but judging from reports I have received from different stations along the Essex coast, it would seem that the number of individuals in a chain will give also the number of years the chain is old. The longest chains contain about as many individuals as years have elapsed since the first appearance of the species. Thus, at West Mersea, the longest chains are composed of thirteen or fourteen individuals, and I estimate that Crepidula would first appear on those grounds about fourteen years ago. Local fishermen will almost certainly underestimate the length of time Crepidula has been present in their locality.

With regard to the destruction of Crepidula on the oyster grounds, it does not seem at all possible to make any sweeping attack on this pest. However, an attempt might be made to make Crepidula saleable by trying various methods of cooking it to make it palatable. In this way Crepidula might come to be rather a desirable acquaintance than an enemy. There would appear to be every likelihood of Crepidula being equal in value to the common Whelk as an article of food. But no doubt the animals should be taken out of their shells before being cooked. After a little practice it is quite easy to take the animal out whole. Fishermen at West Mersea say that Crepidula eats rather tough and bitter, but I was told the limpets were cooked in their shells, so that a good result could not be expected.

Another suggested means of combating the spread of Crepidula is one which might be put into practice at once, if it has not already been adopted, namely, that of encouraging dredgers to bring in the whole of their catches of Crepidula and to destroy them. Possibly, also, something might be done by transplanting enemies of Crepidula into the oyster district, but great care should be taken that the enemies of Crepidula should not turn out to be also enemies of oysters.

The slipper-limpet, however, is not the only animal on the dredging grounds which is an enemy to the oyster. Sea-squirts, other bivalves than the oyster, many worms, barnacles, and all other animals which feed on the material found on or floating near the sea bottom, are likewise enemies of the oyster, enemies in the sense that they compete for food and space. On the other hand, there may be quite enough food on the sea bottom to support all these animals and many more, but at present we have no definite information as to how much of this kind of food there is, although there would seem to be plenty for all.

In the question of how to treat Crepidula, therefore, it would be of great value to have some precise information as to how much oyster food there is on or near the sea bottom, and it is to be hoped that before long the desired information will be obtained.

It has been stated that the presence of Crepidula on oyster grounds is evidence that the grounds are healthy, and there can be no doubt now that this is true, since Crepidula takes the same food as oysters. An interesting confirmation of this statement lies in the fact that inshore Crepidulae at West Mersea are much finer than the specimens obtained on the outer grounds, and it is well known that the inshore oyster grounds are much healthier than those outside.

The substance of this report may now be summed up as follows:—

Crepidula feeds on the same kind of food as oysters, and its presence on oyster grounds may therefore be taken as evidence of the grounds being healthy.

Crepidula takes special care of its spawn. Since all the male Crepidulae change into females, every individual produces in its later life at least 13,000 eggs per year.

The eggs develop into free swimming larvae, which may be scattered far and wide.

Whether Crepidula is harmful to oysters cannot be determined until some measurements have been made of the actual amount of food on the sea bottom, excepting in cases where it occurs in such quantities as to smother the oysters. Crepidula as an enemy to oysters must be put in the same class as the mussel.

There are two main problems to be attended to.

(1) To keep up the food supply of the oysters.

(2) To destroy, besides the oysters' active enemies, as many as possible of those animals which take the same food as oysters, as, for example, the slipper-limpet, mussels, most tube-dwelling worms, other animals similar to the oyster, barnacles, and all the different kinds of sea-squirts.

It should be borne in mind that sea-squirts are nearly as common on some grounds as Crepidula, and that they are just as likely to take away the oyster's food as is Crepidula.

The mode of feeding of Crepidula, with an account of the current-producing mechanism in the mantle cavity, and some remarks on the mode of feeding in Gastropods and Lamellibranchs.

By

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With Figures 1–20 in the text.

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I. INTRODUCTION.

THE manner in which the slipper-limpet, *Crepidula fornicata*, feeds has apparently puzzled all the naturalists who have interested themselves in this animal, as may be gathered from what follows. Crepidula—like its allies the whelks and other pectinibranchiate Gastropods—has a well-developed radula, a fact which leads one to infer that the animal lives a marauding life. But both Conklin and myself have shown that Crepidula settles down permanently at an early age to a sedentary life, so that after settling down the animal must feed on whatever food happens to be in its immediate neighbourhood.

From my studies of the habits and anatomy of this sluggish animal I had formed a hazy idea that, since the gut is very strongly ciliated throughout, food was probably drawn in at the mouth in a current of water. As a result of this idea, I concluded that the radula in later life was an obsolete organ which the animal possessed merely as a heritage from its ancestors. On my expressing this opinion to Dr. Allen, he pointed out that if Crepidula possessed an obsolete but well-developed radula, then the phenomenon appeared to be a new one, which required to be carefully investigated. Subsequently a careful examination was made of the gut contents of Crepidula, and a comparison established between these and the ingested food of the native oyster, *Ostrea edulis*, taken from the same grounds, namely, off the Essex coast in the Blackwater near West Mersea. It may be here remarked that as Crepidula has spread so rapidly on the oyster grounds off the Kent and Essex coasts as to become a nuisance, it has become a matter of much importance to oyster farmers to have definite information about its food. The examination made of the gut-contents of these two animals revealed a close similarity in the kind of food-material, as far as skeletal remains indicate, and the identity of the most common forms of diatoms found in both animals. The contents of the gut of both these animals are mainly:

1. Sand-grains.
2. Sponge-spicules.
3. Diatom shells.
4. Vegetable debris, Radiolarian, Foraminiferan, and Peridinian tests.

The most common diatoms* present in both animals are:

† *Actinoptychus undulatus*, Bail.
† *Paralia sulcata* (Ehr.).
Navicula aspera, Ehr.
Cocconeis scutellum, Ehr. and a var. parva?
Hyalodiscus stelliger, Bail.
Actinocyclus ralfsii (Wm. Sm.).

Among the less common, but, in the case of some of the larger, equally important forms are several species of †Coscinodiscus, Nitzschia, Navicula, and Grammatophora, and occasional specimens of a few other species. As the majority of these forms were found living in the washings from the shells of Crepidula and the oyster, there is no doubt that the animals were feeding on at least most of the forms mentioned. A species of Prorocentrum, probably *P. micans*, was however the organism found in the greatest numbers in the gut of these animals at the time they were examined, i.e. about the month of October, 1911.

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* For the identification of diatoms, works by Van Heurck (3) and Gran (4) were consulted.

† It is not surprising to find these plankton forms amongst the food of these animals. Both Crepidula and oysters were taken from depths of only a few fathoms and not far from the shore. In such a situation as this the plankton will doubtless be much mixed up with bottom-living organisms.

It therefore became evident that Crepidula takes the same kind of food as oysters, and as the oyster has no radula, I appeared to have gained my point about the radula of Crepidula, namely, that it is a useless organ. However, while examining Crepidula one evening I detected a current in the mantle cavity, and subsequently observed the mode of feeding, which established beyond doubt both the nature of the food-material and the use of the radula, as will be shown in the following account.

II. THE MODE OF FEEDING IN CREPIDULA.

Crepidula feeds in the same way in principle as the oyster—that is, an ingoing and an outgoing current of water is established in the mantle cavity along a definite pathway, while between the two currents the gill acts as a strainer, retaining even very fine particles of suspended matter which may eventually reach the mouth. The gill consists of a row of free filaments—more than four hundred filaments were counted in the gill of an adult specimen—placed parallel to one another, midway between the dorsal and ventral surfaces. The filaments stand out in a line along the left side of the mantle cavity, extending almost in a horizontal line across this cavity; their tips rest along the edge of the right epipodium anteriorly, but posteriorly on the dorsal surface of the visceral mass. The gill thus forms a sheet across the mantle cavity, which it divides into a left ventro-lateral inhalent chamber, and a right dorso-lateral exhalent chamber. Fig. 1 gives a ventral view of the animal in the act of feeding; the arrows indicate the direction of the food-current. In feeding, the front end of the shell is raised slightly and a current is set up in the mantle cavity by the cilia on the gill-filaments. Water is drawn in along the anterior half of the edge of the shell on the left, passed through spaces between the gill-filaments, and is expelled along the front half of the edge of the shell on the right (see Fig. 1).

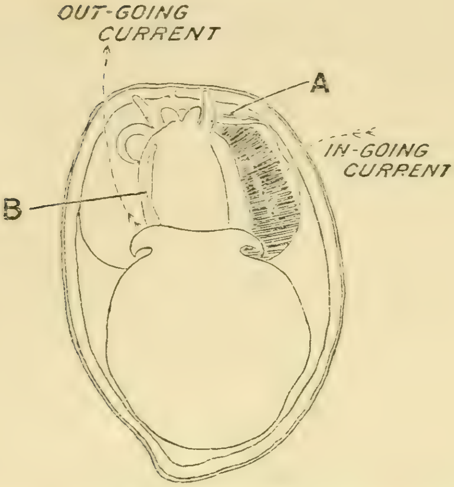

Fig. 1.—Ventral view of Crepidula. The arrows indicate the direction of the food-current. (Drawn from life. × 2.)

A. Food-pouch for the coarse food-particles; the main part of the pouch is hidden from view by the animal's "head."

B. Cylindrical mass of food in the food-groove; seen through the translucent body-wall.

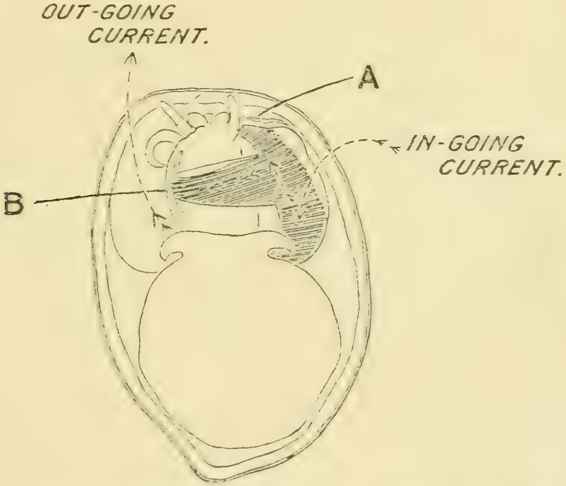

Fig. 2.—Ventral view of Crepidula with a part of the "neck" region supposed to be cut away to show the gill lying over the back of the animal.

A. Food-pouch.

B. The pointer points at the exposed tips of a few gill-filaments, just in front of which can be seen the food-groove in section.

The little arrow between the cut surfaces of the animal indicates the direction in which the fine food-particles travel.

Most of the fine particles of suspended matter are carried by the current against the gills, and being caught by the cilia of the gill-filaments or in the mucus secreted by the gill, are hurried along the ventral face to the tip of the gill. (See the small transverse arrow in Fig. 2.) Upon reaching the tips of the filaments the food is deposited in a ciliated groove, which runs along the right side of the body (see Fig. 2, B). This ciliated food-groove is just roofed in by the tips of the filaments. These are flattened at this point the more effectively to close in the groove (see Fig. 3), and just meet the slightly upturned edge of the right epipodium.

The food collected in this way becomes embedded in mucus and formed into a cylindrical mass (see Fig. 1, B), which is at intervals passed forward towards the mouth to be eaten. As the food-mass approaches the mouth the animal shoots out the radula at it with the marginal teeth spread apart, but on striking the food-mass these teeth close in, and in this way obtain a hold on it. The radula is now retracted and the food is thus drawn into the pharynx where the mandibles assist in retaining it. The radula is then freed and again shot out at another part of the food-mass, grasping and drawing back another length. These operations are repeated until a length of the food-material is broken off from the main mass. The detached piece is then swallowed.

This is not the only way, however, in which food reaches the mouth. The majority of the larger particles of food-material, which are drawn in with the food-current, have a different fate. On entering the inhalent chamber they can be seen to be drawn forwards in a direction almost at right angles to the main current (see the small arrow in Figs. 1 and 2), and become gathered together in the food-pouch which is placed just in front of the mouth (see Figs. 1, A, 2, A, 4, A). In this pouch, which is really a deep groove in a semicircular fold of skin, the food is worked up with mucus into a pellet which may be eaten, but if considered undesirable as food, it is carried by cilia to the edge of the shell or pushed by the animal into the exhalent current. And, indeed, when a large quantity of food-material is suddenly drawn into the mantle cavity, the animal usually rejects the greater part of it by backing into the cavity, covering the gills posteriorly so as to cut off most of the current, and at the same time secreting a copious supply of mucus, in which the intruding material becomes caught, and carried in the current forwards. But instead of passing into the food-pouch, it is carried further forward into a ciliated path which is situated immediately in front of and parallel with the food-pouch and deposited at the extreme front of the shell (see Fig. 4, A). It has been noticed that the food-material gathered in the food-pouch is often rejected, while that in the food-groove is almost always eaten. Thus the food-pouch and forwardly directed current are a means for separating and transferring to the region of the mouth the larger food particles, and at the same time they may be utilized by the animal for getting rid of such heavier undesirable particles as may be taken into the inhalent chamber.

The mode of feeding may be easily observed by inducing individuals to attach themselves to glass, so that if fine particles of some coloured substance be added to the water, the whole of the details of the operations can be seen through the glass. Carmine powder suspended in a solution of methylene blue in seawater gives a good result, as the latter stains the mucus a little, and makes its presence the more easily detected. From the foregoing account of the mode of feeding of Crepidula there remains no doubt that Crepidula takes the same kind of food as the oyster.

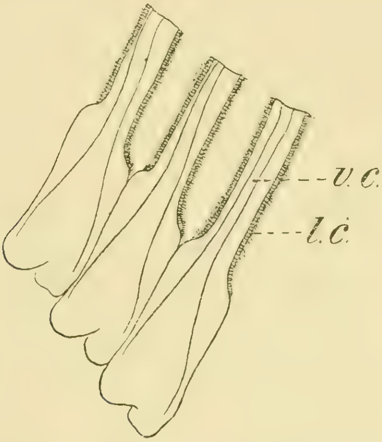

FIG. 3.—Ventral view of the tips of three gill-filaments from the anterior region. (Drawn from the living animal. × about 90.)

v.c. Ventral edge of the filament: the cilia are not represented.

l.c. Lateral cilia.

The notch in the tip of the filament permits the passage of food-particles to the ventral surface.

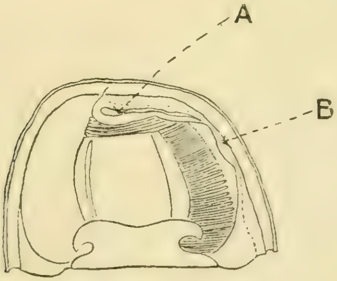

FIG. 4.—Ventral view of the anterior half of Crepidula with the "head" of the animal supposed cut away in order to show the food-pouch.

A. Food-pouch.

B. The ciliated path is represented by the dotted line.

III. MECHANISM CAUSING THE FOOD-CURRENTS IN CREPIDULA.

The main food-current is produced by the lashings of rows of cilia on the anterior and posterior faces of the gill-filaments. The filaments, it has been noted, stand out in a row from the left side of the mantle (seen in Figs. 1 and 2 below the small arrow), being each supported internally by a pair of chitinous rods (see Fig. 5, C). They are free, and placed a little distance apart so that water can pass between them. When examined separately they are seen to be flattened antero-posteriorly (see Fig. 5), except at the tips, where they are flattened dorso-ventrally, so that at this part they touch the adjoining ones (see Fig. 3). In this way, it may be noted, the filaments form a complete roof to the food-groove (see Figs. 1 and 2, B). In transverse section the filaments are seen to have four rows of cilia (see Fig. 5), namely anterior, posterior, dorsal and ventral rows (compare Fig. 6). The anterior and posterior rows are formed by far the stronger cilia both in appearance and action. These lash the water from the ventral to the dorsal face of the gill, and are the chief producers of the main food-current (see Figs. 5 and 6, l.c.). For convenience of reference the anterior and posterior rows may be referred to as the "lateral" rows. The ventral and dorsal rows of cilia lash the water along opposite faces of the gill-filaments towards the tips, i.e. from left to right (see Fig. 6). Both ventral and dorsal rows gather the fine particles and deposit them in the food-groove, but the anterior and posterior rows also assist in this process, as may sometimes be seen when examining a living filament under the microscope, or even when examining the living animal with a lens. Therefore, when cilia of the anterior and posterior rows wash food towards the food-groove, the direction of their lashing is changed from a ventro-dorsal to a laevo-dextral one. This is a point of some interest, and apparently the stimulus inducing the change of motion is supplied by the particles merely touching the cilia.

The way in which the different rows of cilia act may be gathered from a glance at Fig. 6, which is a sketch of the end of a gill-filament.

If such a piece of a filament be cut off—without the flattened tip—and observed in water it will be seen to swim, when unimpeded by mucus, in the direction indicated by the lowest arrow in the figure. This direction, relative to the long axis of the gill, gives some idea of the relative strength of the lateral rows of cilia as compared with the dorsal and ventral rows, for the direction is, of course, the resultant of the action of the two sets of cilia. Hence it is apparent that the lateral cilia are by far the stronger, just as one would expect to find, seeing that they have to draw a current of water through the mantle cavity, while the other rows merely pass on the food-particles.

The ventral rows of cilia lash in a direction from left to right, and, as has already been remarked, are the main collectors of the fine food-particles. The dorsal rows of cilia lash in the same direction as the ventral rows, but on the opposite face of the gill; whatever particles are passed on to them by the lashings of the lateral cilia they wash along the dorsal face of the filament, through a notch in the tip of the latter (see Fig. 3), and round to the large cilia on the ventral surface (see Fig. 6). The dorsal cilia, however, also assist in maintaining the food-current, and in modifying the direction of the current formed by the "lateral" cilia, for a glance again at Fig. 6 will show that the resultant direction of the water current produced by all the cilia on the gill is in a direction opposite to that in which the free filament swims. Thus, in the living animal the effect of the dorsal cilia on the current on its passing through the gills is to turn it towards the right, namely, towards the exhalent aperture (see Figs. 7 and 8). The groups of large cilia on the ventral tips of the filaments are probably the chief agents in pushing the collected food forwards towards the mouth, being assisted in this by the cilia in the food-groove. The tips of the filaments are covered all over with cilia; those on the anterior and posterior faces doubtless assist in interlocking the filaments.

In connection with the gill-filaments, there still remains to be considered the action of those cilia which occur on the floor of the posterior part of the mantle cavity, that is, on that part of the mantle lining the dorsal surface of the visceral mass. In this region the cilia wash particles from left to right into a ciliated path on the right side, which path is continuous with the food-groove (see Fig. 2, B) in the anterior region. The mantle to the right of the ciliated path bears cilia which lash particles into the same path, working however in a direction mainly dorso-ventral.

The cause of the forwardly-directed current at the anterior end of the inhalent chamber is found in the presence of strong and active cilia on the lips of the food-pouch, on the inner side of the mantle, and especially those on the dorsal surface of the left epipodium. The food which is washed forwards by these groups of cilia is directed into the food-pouch chiefly by the cilia on the dorsal lip of the latter, but it is pushed along inside the pouch by cilia, being assisted in this, however, by slow, wave-like pulsations of the side-walls. In the capture of food-particles there is no doubt that the secretion of mucus for entrapping the particles is a very important factor, and a more correct

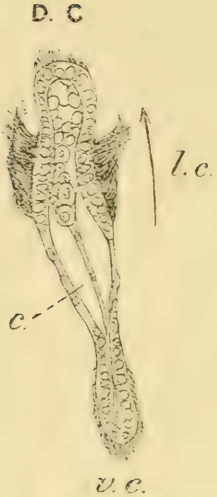

FIG. 5.—Transverse section of a gill-filament of Crepidula from the visceral region. (× about 67.)

D.C. Dorsal cilia; l.c. Lateral cilia, which lash in the direction indicated by the arrow; v.c. Ventral cilia; c. Gill-filament supports.

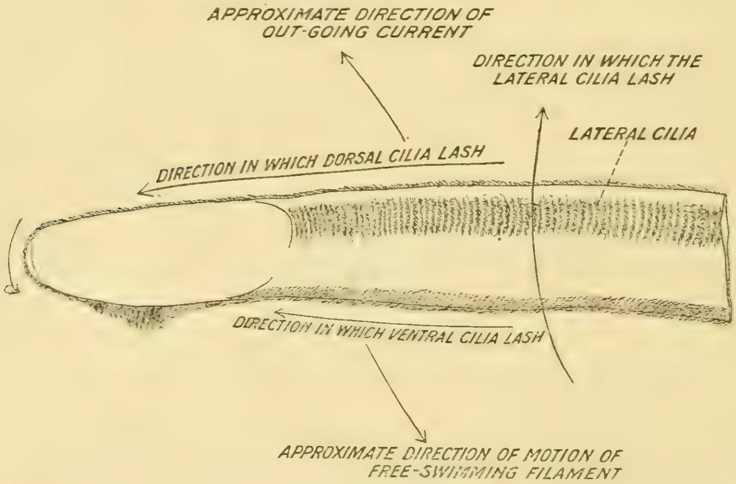
APPROXIMATE DIRECTION OF OUT-GOING CURRENT
DIRECTION IN WHICH THE LATERAL CILIA LASH
LATERAL CILIA
DIRECTION IN WHICH DORSAL CILIA LASH
DIRECTION IN WHICH VENTRAL CILIA LASH
APPROXIMATE DIRECTION OF MOTION OF FREE-SWIMMING FILAMENT

FIG. 6.—Posterior view of a gill-filament of Crepidula. (Drawn from a living filament of Crepidula. × 50.)

idea of the forward movement would be conveyed if one imagined a sheet of mucus bearing the food-particles being both drawn and passed onwards into the food-pouch.

The question now arising as to why the larger food-particles should be caught in mucus and carried forwards, while the finer particles travel onwards to the gill, is easily answered, but it is necessary first to obtain a fair idea of the spacial relation of the inhalent chamber. Fig. 7 is a transverse sectional diagram of the inhalent chamber, and Fig. 8 a longitudinal sectional diagram, A in both figures indicating the position of the forwardly directed stream in the inhalent chamber.

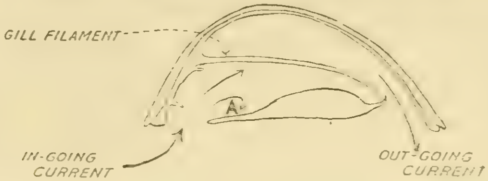

FIG. 7.—Diagram of the special relations of the mantle cavity of Crepidula in transverse section, taken just anterior to the propodium.
A indicates the position of the forwardly directed stream.

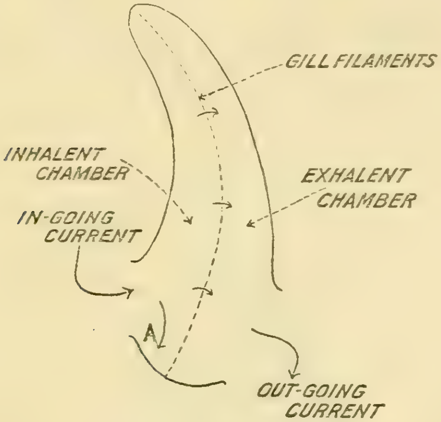

FIG. 8.—Diagram of the general spacial relations of the mantle cavity of Crepidula in median longitudinal section. The inhalent and exhalent apertures are represented, although not actually occurring in the section.
A indicates the position of the forwardly directed stream.

It will be seen that the area of the inhalent aperture is relatively small, and that there is a sudden widening out at this point of the path of the inhalent stream. Consequently, when a current is passing through the mantle cavity the velocity of the stream must fall just inside the inhalent chamber, and as a result the larger particles tend to lag behind and sink in the stream. As they sink they come within the influence of the forward stream caused by the cilia on the food-pouch, mantle and left epipodium, and becoming eventually caught in this stream (see the small arrow A in Figs. 7 and 8) are carried forwards into the food-pouch. From the disposition of the cilia causing the forward stream, it is possible for the coarser food-particles always to be carried forward, no matter whether the animal be placed upside down or any other way, but if the animal be upside down a fairly copious secretion of mucus becomes necessary to capture the particles. In the normal position of the animal, however, that is, with the ventral surface downwards and facing a little to the left, the disposition of the parts is beautifully effective for separating the heavier food-particles, as may be gathered from diagram (Fig. 7). From this diagram it will be seen that the heavier particles are dropped into the ciliated path on the left epipodium, and so may be passed forwards while the lighter particles are carried onwards in the stream above. The cilia on the left epipodium are only a part of the uniform covering of cilia on the dorsal surface of the animal's "head" and "neck." The disposition of the cilia on the remaining parts, and the directions in which these lash, may be gathered from a glance at Fig. 9. It will be noticed that the cilia on the right side assist in washing particles into the food-groove, while those on the dorsal surface of the "head" assist in transferring food-particles to the food-pouch; for it will be remembered that the animal's head, as in Fig. 1, overlies the food-pouch.

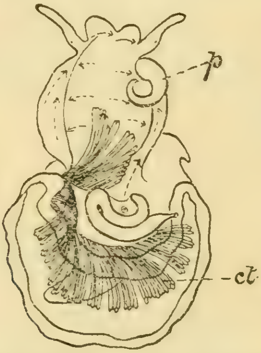

Fig. 9.—Dorsal view of a male Crepidula taken out of its shell and drawn from life, with the mantle turned back. The arrows indicate the directions in which the various groups of cilia lash. (Natural size.)
ct. Gill filaments.

IV. SUMMARY OF ACCOUNT OF CURRENT-PRODUCING MECHANISM, AND MODE OF FEEDING IN CREPIDULA.

The mode of feeding in Crepidula is thus seen to be as follows:—A main food-current is produced through the mantle cavity by the lashings of rows of cilia on the anterior, posterior, and dorsal surfaces of the gill-filaments; the current entering the mantle cavity on the left at the front of the shell passing between the gill-filaments and out at the front of the shell on the right. On entering the inhalent chamber, however, the velocity of the stream falls owing to the widening out of its path, so that while the heavier food-particles tend to be dropped out of the current, the lighter particles travel onwards towards the gill. On coming in contact with the gill these particles are either caught by the cilia or in mucus secreted by the gill, and swept by the rows of cilia on the ventral and dorsal faces of the gill-filaments towards the tips of the latter, and deposited in a ciliated groove on the right epipodium, which groove is efficiently roofed in by the flattened tips of the filaments. In the groove the food becomes worked up with mucus into a cylindrical mass which at intervals is passed forwards towards the mouth to be eaten. In the process of eating the food is seized and drawn into the buccal cavity by means of the radula, and there retained by means of the mandibles prior to being swallowed. The heavier food-particles, however, reach the mouth by a different route. On falling out of the main stream they are caught in the forwardly directed stream caused by the combined lashings of several groups of cilia, namely, those on the left dorsal region of the animal's "head" and "neck," those on the face of the food-pouch, and those on the left anterior border of the mantle. This stream is directed into the pocket of the food-pouch by the cilia on its dorsal lip where the captured food becomes worked into a pellet and deposited in front of the mouth for eating. If, however, the animal is not wanting food, the entrance to the food-groove is closed, and the stream is directed out of the mantle cavity by way of a ciliated path parallel to the left anterior edge of the mantle. In front, this ciliated path runs parallel with the pocket of the food-pouch (see Fig. 4, B), but behind, it is placed on a fold of skin somewhat similar to that forming the food-pouch. If a large quantity of foreign material be drawn into the mantle cavity, the ciliated path may be formed into a channel by the infolding of the edge of the fold on which the path lies posteriorly, but in front by the raising up of the mantle along the sides of the path. At the same time, the animal shuts off the food-current by closing the mantle cavity, and by covering the gill by the body, confines the intruding material to the forwardly directed stream, and is then able to reject it. Should large bodies get into the mantle cavity, the animal tries very hard to get behind them, and when it does so, pushes the intruding material bodily in front of the lips and extended tentacles out of the apparently sacred precincts of the inhalent chamber into the exhalent chamber, or even right outside the mantle cavity. Intruding air-bubbles have often been seen to give the animals great trouble in this way. In trying to clear the chambers the animal shows some ingenuity in trying different plans, but apparently also some stupidity in not widening the exits by raising the shell, and so making its task an easy one.

V. FUNCTION OF THE RADULA IN CREPIDULA.

In the process of feeding it will now be seen that the radula plays a very important part; it is used for seizing and conveying to the pharynx all the food that the animal takes; while the mandibles, it may be noted, assist in retaining the food temporarily in the pharynx.

Thus the radula of Crepidula, far from its being, as I thought, an obsolete organ, is one which is in constant use and of the first importance in the life of the animal, but, instead of its being used for rasping, as in its allies and presumably in its ancestors, it is now used for grasping. The function of the radula in Crepidula has therefore changed, and the failure to imagine the probability of such a change led me to a wrong conclusion with regard to its present importance to the animal. The change in function is, however, interesting, as it adds one more instance to the economy practised by nature in making use of the material that is to hand. Signs of degeneration in the radula are nevertheless appearing, as may be gathered from the following independent observations by Haller (5): "Die Auffallende kurze Radula (*of species of Crepidula*) liegt in einem sehr dickwandigen Radularsacke. Der Munddarm und die Buccalmasse ist bei allen von mir un tersuchten Calyptraeiden ungemein klein." Hence one might expect to find among the allies of Crepidula some forms which are evolving out of their radular apparatus a more efficient organ adapted to the present needs; and such a change is the more to be expected as the radula is a specific variant in the group to which the animal belongs.

VI. RESEMBLANCE OF THE FUNCTION OF THE GILL OF CREPIDULA TO THAT OF THE LAMELLIBRANCH GILL.

A change in function—or rather an additional function—has also been taken on by the gill of Crepidula. The ancestral gill was probably mainly an organ of respiration, but now the gill serves also as a food-collector. The gill of Crepidula has, therefore, exactly the same function as that of typical Lamellibranchs. The phenomenon is thus apparently presented of two independent trends of evolution arriving in principle at exactly the same result: both groups of animals having utilized the respiratory organ in a similar way as a water-pump and as a food-sieve.*

VII. THE MODE OF FEEDING IN THE OYSTER AND OTHER LAMELLIBRANCHS.

The mode of feeding in Lamellibranchs has been described by several writers. Stenta (6) described a number of forms fairly fully. Kellogg

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* If, however, the gill of the ancestors of Lamellibranchs and Gastropods were already a food-collecting organ—as seems possible from the observations here made on the gill of Nucula and many Gastropods (see pp. 467–73)—then the "convergence" is homogenic and not homoplastic.

(7 and 9) has treated other forms in more detail; and about the same time Herdman and Hornell (10) described the mode of feeding in the Ceylon pearl oyster.

The following description of the mode of feeding in the European oyster contains little that has not already been noted by these writers in similar forms. The native oyster (*Ostrea edulis*) draws a food-current into the mantle cavity between the mantle lobes antero-ventrally. The current does not enter along the whole of the ventral surface, however, when the animal is feeding normally, but only in a small restricted part such as is indicated in Fig. 10. It is only in this part that the ventral edges of the mantle lobes are not apposed, and the opening thus produced forms practically an inhalent aperture. The outgoing current leaves the mantle cavity postero-dorsally (see

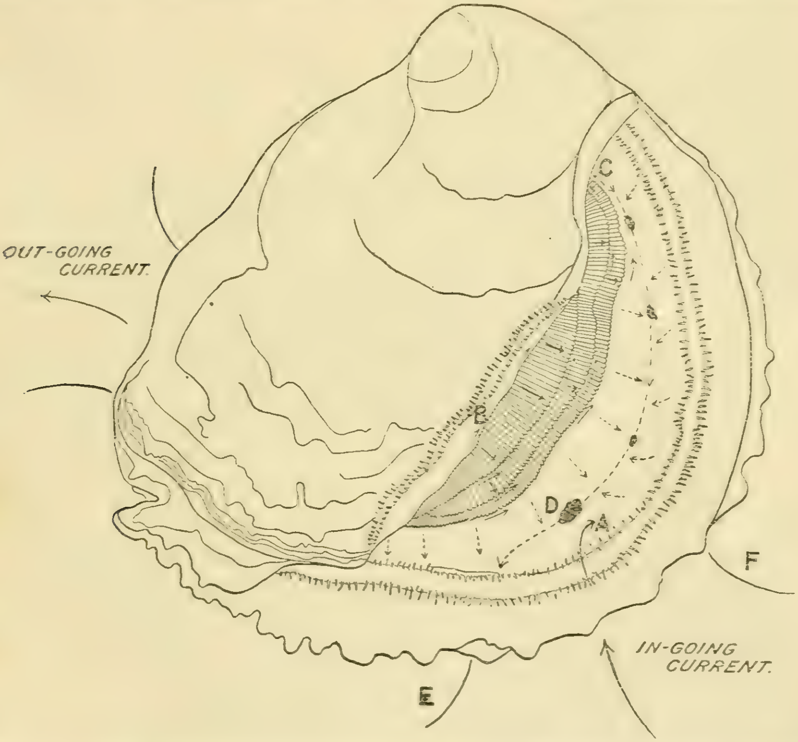

FIG. 10.—View of mantle cavity of the native Oyster (*Ostrea edulis*) from the right side to show the food currents. (Drawn from life, natural size.)

The ingoing current enters the mantle cavity between the points E and F.

The dotted arrows indicate the directions in which the mantle cilia lash.

The arrows on and at the edges of the gill-lamellae indicate the paths of the main food-streams.

A. Point at which the heavier particles begin to fall out of the main food-stream.

B. Minor food-stream at the base of a gill-lamella.

C and D. The ciliated path on the mantle which carries away food-material rejected by the palps and the particles collected from the mantle.

E and F. Region in which the oyster commonly takes in its main food-stream.

Fig. 10). On entering the mantle cavity the path of the ingoing stream is suddenly widened (see Fig. 14) and, as is the case in Crepidula, the heavier particles drop out of the current. These particles, however, are collected by the mantle cilia into a definite ciliated path, the cause of the "untere Rückenström" of Stenta, which conducts them posteriorly to a point in about the middle of the inhalent chamber (see Fig. 10), whence the intruding material is expelled at intervals by sudden flappings of the shell-valves. This stream is protected, or rather rendered possible, by the infolded mantle edges, which shield it from the main stream. Those particles which fall on the mantle in the posterior part of the inhalent chamber are washed ventrally, and are either shot out of the mantle cavity at any point, as indicated by the arrows in Fig. 10, or are caught up by the gill and carried forwards towards the mouth.

In the American oyster there is a similar, posteriorly-directed ciliated path on the anterior half of the mantle, but according to Kellogg (7) there is also in the posterior half of the inhalent chamber a forwardly-directed current, which carries intruding bodies forward to the point where the current in the anterior part deposits whatever material it may have collected. The whole of the foreign particles collected by the mantle are then expelled at the point where the two paths meet, that is, in about the middle of the edge of the inhalent chamber.

In Mytilus and Cardium (see Stenta, 6) the ciliated path collects particles from the whole of the mantle and washes them posteriorly into the exhalent chamber, but here, as also in *Glycimeris glycimeris*, the inhalent and exhalent apertures are more definite than in the oyster, both apertures, however, being posterior (see Figs. 11 and 12). The ciliated paths in Cardium and Mytilus are excellently arranged for expelling intruding bodies, for in the natural feeding position these animals lie with the ventral surface apposed to the substratum, and the current enters the mantle postero-ventrally. Hence the whole length of the mantle cavity is utilized for the weeding out of the heavier particles, which on falling out of the current drop straight into the ciliated paths. Moreover, there is in Mytilus in the dorsal angle of the inhalent aperture a fold of epidermis forming a sort of curtain (see Fig. 11, B) which prevents the ingoing current from impinging directly on to the gills by directing it ventrally. In this way there doubtless results a more effective selection of the coarser particles. In Cardium a semicircular fold of the mantle between the inhalent aperture and the posterior ends of the gills (see Fig. 12, B) doubtless assists in the automatic selection of the heavier food-particles in the same way as the "curtain" in Mytilus. In Pecten water is drawn into the mantle cavity along the whole of the ventral and part of the anterior surface, but chiefly in two restricted areas. One of these areas is indicated by the large arrow pointing to B in Fig. 13, and the other is shown approximately by the large arrow passing near A, Fig. 13. The ciliated path on the mantle in Pecten collects particles from the whole of the ventral region of the mantle (see the dotted line C A B in Fig. 13) and washes them anteriorly to the edge of the mantle (see Fig. 13, B), whence they are expelled along with the material rejected by the palps.

While the heavier particles are dropped out of the current just inside the mantle cavity in the oyster, the finer particles travel onwards in the stream until they reach the gill, which retains them while allowing the current to pass onwards into the exhalent chamber. The food-particles drawn against the gill-filaments are caught in the mucus secreted by the gill and washed to the distal edges of the gill-lamellae, where they are formed into a cylindrical mass. This mass is then pro-

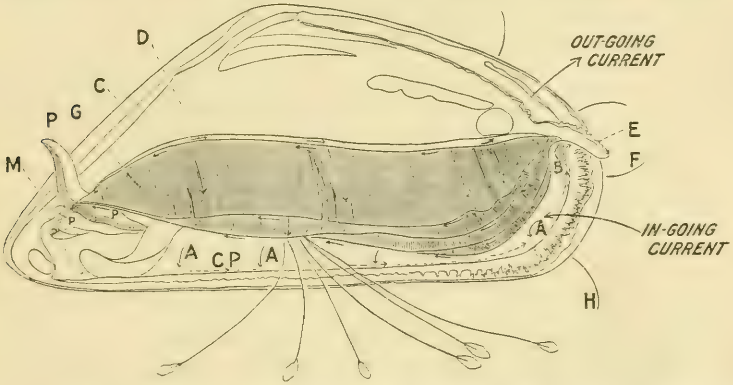

FIG. 11.—View of the mantle cavity of the common mussel, *Mytilus edulis*, from the left side to show the food-currents. (Drawn from life, about natural size.) The arrows on and at the edge of the gill-lamellae (G) indicate the paths of the main food-streams.

C.P.	The dotted arrows and line at the ventral edge of the mantle indicate the ciliated path which carries the material rejected by the palps and that collected from the mantle to the point indicated by the arrow above B in the figure. Here the rejected material is pushed into the exhalent current.
A.	Arrows indicating the paths of the heavier particles settling out of the main food-stream.
B.	A sort of curtain hanging from the dorsal part of the inhalent aperture.
C.	The line of attachment of the mantle to the body-wall.
D.	Arrows in the supra-branchial chamber indicating the direction of the exhalent current.
E.	Uplifted left border of the inhalent aperture to show the curtain, B.
F.H.	Points between which the main food-current is drawn into the mantle cavity.
G.	Left outer gill-lamella.
P.P.	Left palps between which the edges of the left gill-lamellae may be seen to end.
P^1P^1	Right palps.
M.	Locus of the mouth.

pelled along its somewhat precarious journey towards the palps by the cilia in the open food-groove which is found along the distal edges of the gill-lamellae of the oyster, and indeed of most other Lamellibranchs (compare Figs. 14 and 15).

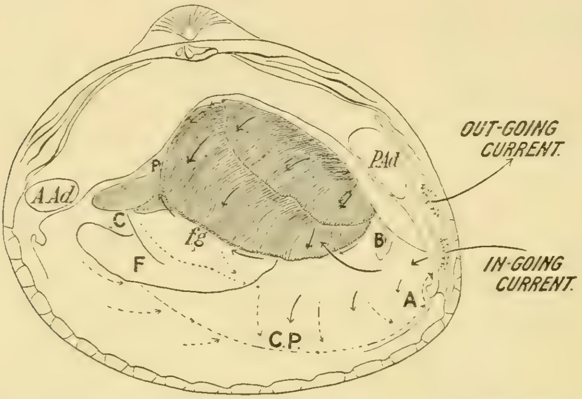

Fig. 12.—View of the mantle cavity of the common cockle, *Cardium edule*, to show the respiratory current and the currents connected with the mode of feeding. (× $\frac{3}{2}$.)

C.P. Ciliated path on mantle which carries away the material rejected by the palps and that collected from the mantle.
A. Point at which heavier particles begin to drop out of main stream on to mantle, and also the region on the mantle whence the material collected by the ciliated path is finally shot out of the mantle cavity.
B. Gill-shield directing the ingoing current ventral-wards.
C. Point at which material is passed from the palps to the mantle.
fg. Food-groove at the ventral edge of the inner gill-lamella.
P. Left outer palp, below the base of which lies the mouth.
A. Ad. Anterior adductor. P. Ad. Posterior adductor.
The dotted arrows on the mantle and foot indicate the directions in which the cilia lash.
The arrows on and at the edge of the gill indicate the paths of the food-streams.

Such food-streams occur at the tips of the four lamellae, at the bases of and between the lamellae, and also between the outer lamellae and the mantle (see Fig. 14). The particles in the basal streams are mostly washed to the tips of one or other of the gill-lamellæ before reaching the palps, but in any case the streams on each side of the body eventually pour their burdens on to the palps, whence they are conveyed either to the mouth or directed into the ciliated paths if deemed undesirable as food (see Figs. 10 and 14). If the food is accepted, the palps separate so as to allow it to pass between. The cilia on the inner surfaces of the palps then quickly wash the food into the mouth. If the food is rejected, the palps remain apposed, and the cilia on their outer surfaces direct the food-mass on to the ciliated path on the mantle whence it is conveyed outside the mantle cavity.

In Pecten and Mytilus the upturned edges of the outer gill-filaments touch the mantle during feeding, and in this way form at this point a temporary food-groove. Otherwise the food-streams in these forms are similar to those of the oyster. In Cardium the frontal cilia on the outer gill-lamellae lash towards the edge of the gill on the outer faces

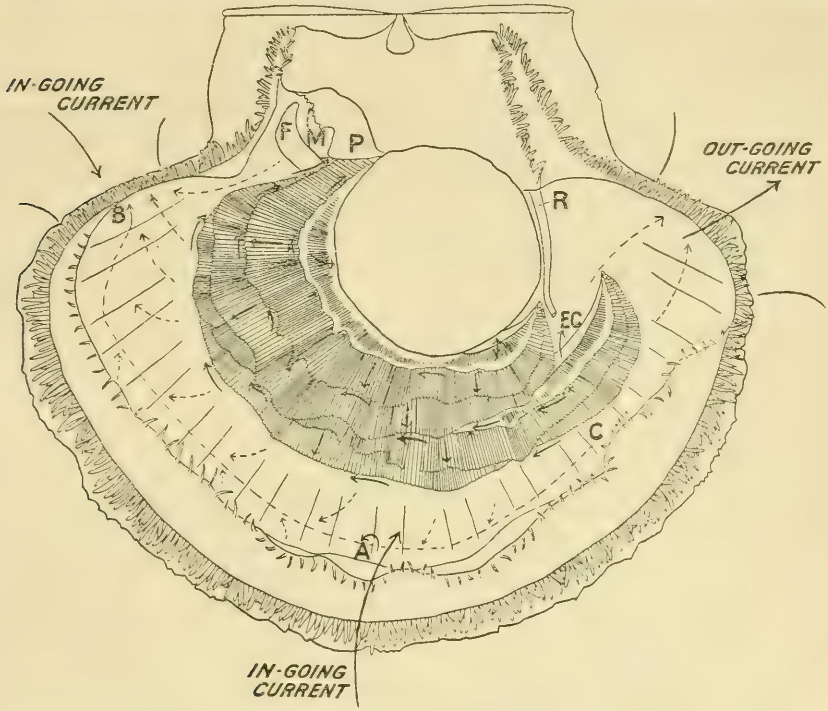

*FIG. 13.—View of mantle cavity of the scallop, *Pecten maximus*, to show the food-streams, seen from the left side with the mantle supposed to be cut away. (Drawn from life, natural size.) The posterior ends of the gills are somewhat retracted. In feeding, these spread across to the edge of the mantle and divide the cavity into inhalent and exhalent chambers.

The *dotted arrows* indicate the directions in which the mantle cilia lash, and the dotted line on the ventral part of the mantle between A and B indicates the ciliated path.

The *small arrows* at the edges of the gill-lamellae and of the reflected filaments indicate the paths of the main food-streams which lead to M, the region of the mouth. The arrows at the proximal ends of the gills, as at E C, indicate the direction of the exhalent current.

A. Point at which the heavier particles settle out of the main food-streams.
B.C. The ciliated path on the mantle.
E.C. Exhalent currents.
F. Foot.
M. Region of mouth.
P. Left outer palp.
R. Rectum.

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* I am indebted to Mrs. Orton for this drawing, for assistance in the drawing of the oyster (Fig. 10) and also Fig. 14.

but towards the base of the gill on the inner faces. On the inner lamellae the frontal cilia on both faces lash particles towards the free edge of the gill into a well-defined food-groove. In Pecten, Kellogg has described that in the troughs of the gills particles are lashed towards the base of the gill, while on the crests particles are lashed towards the edge. On the other hand, Stenta has shown that in Anodon food-particles are washed towards the bases of the outer lamellae but to the tips of inner lamellæ. All these different modes of food collection and transportation may be indicated in diagrammatic form as in Fig. 14. This diagram will also indicate the mode of food-collection and food-transportation in Nucula. I find that in Nucula the gills divide the posterior region of the mantle cavity into infra- and supra-branchial chambers as in the higher Lamellibranchs. The

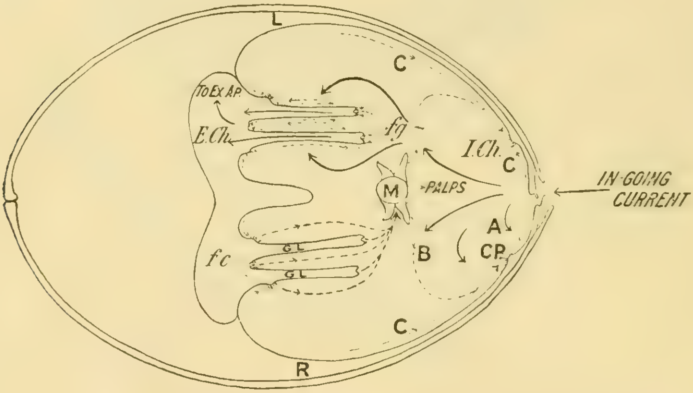

Fig. 14.—Diagram of the general mode of feeding in Lamellibranchs.

The large thick-lined arrows indicate the paths of the main respiratory and food-current.

The dotted thin-lined arrows indicate the directions in which the mantle and gill cilia wash the food-streams. The dotted thick-lined arrows leading from the right gill-lamellae indicate the paths of the main food-streams towards the mouth.

Food-collection is indicated on the left gill-lamellae, and food-transportation on the right gill-lamellae.

A. Point at which the heavier particles begin to settle out of the current.
B. The ciliated path on the mantle which carries away material rejected by the palps, and that collected from the mantle.
C.P. The ciliated path seen in section on the mantle.
C. The subsidiary mantle streams.
L. & R. Left and right valves of shell, and the beginning of the left and right mantle lobes.
f.g. Main food-grooves.
f.c. Food-channels at bases of gills.
I.Ch. Inhalent chamber.
E.Ch. Exhalent chamber.
G.L. Gill-lamellae.
M. Mouth.
To Ex. Ap. To exhalent aperture.

inner edges of the inner leaflets are apposed and kept interlocked by groups of large cilia (see Fig. 18, I.c.d., p. 468). The outer edges of the outer leaflets and the posterior ends of the gills effect similar ciliary junctions with the mantle by means of groups of large cilia (see Fig. 18, O.c.d.). In this way a complete partition of the mantle cavity is effected, and the ventral surface of this partition is utilized as in the higher Lamellibranchs for food-collection. Food-particles brought to the gill in the main current are arrested by the gill and washed along the edges of the leaflets from the outer leaflet to the inner (see Fig. 18). At the ventral end of the inner leaflets of both sides the collected food is washed anteriorly towards the mouth. Food-particles collected from the gill in this way appear to be gathered up by the appendages of the palps and transferred to the palps, which pass it along into the mouth. Food-particles may be rejected by the palps in Nucula in the same way as in other Lamellibranchs. Rejected food is pushed off the posterior end of the palps on to the foot, and off the posterior face of the foot on to the mantle. The mantle cilia in Nucula collect particles into anterior and posterior ciliated paths which converge at the middle ventral edge of the mantle just as in the American oyster. The observations on the mode of feeding in Nucula are still being carried on. In the light of the observations already made on Nucula, and especially of those on the ciliation of the gill (see page 467), it would be worth while to re-examine the mode of feeding in Yoldia. Drew (11, pp. 15 and 16) was unable to find out whether Yoldia uses its gills otherwise than for pumping water. If, however, the whole gill be examined alive while feeding it with carmine, the secret would soon be out. It is possible that the gill in this form may not be used for food-collecting, and if not, the condition is more interesting than if it is so used. However, from one of Drew's figures of the gill of Yoldia, although a general view (11, Fig. 20), there is good reason for believing that food-collecting occurs in the same way as is described here for Nucula.

VIII. AN EXPLANATION OF THE DIRECTION OF EVOLUTION IN LAMELLIBRANCHS.

The mode of feeding in Lamellibranchs, it will now be seen, necessitates the sedentary habits which are exhibited by most members of this group. Moreover, there can be no doubt that adaptation to the mode of feeding has been at least one of the main factors in determining the direction of evolution in Lamellibranchs. From the foregoing account of the gill of Nucula, it is clear that the gill in this form presents an early stage in the adaptation of the original respiratory organ to a food-collecting organ; and further, recent work (see Pelseneer, 12, pp. 253–4, and Ridewood, 13) has confirmed the conclusion that the higher Lamellibranchs have evolved mainly on the principle of folding and consolidating the originally simple free gill-filaments to form gill-lamellae. It will now be seen to be highly probable that this complication and fusion of the gill-filaments is an adaptation for the purpose of obtaining a more efficient feeding organ. Folding of the gill-filaments dorso-ventrally into demibranchs and—incipiently—antero-posteriorly into crests and troughs has increased the food-collecting surface, while fusion of the filaments first by ciliary junctions and afterwards by organic connections has rendered the food-collecting organ less liable to derangement. In the Filibranchs there is much danger of the gill-filaments becoming separated, whereby the continuity of the food-grooves at their tips is broken. As a result the animal may have difficulty in feeding, and its nourishment be thus seriously interfered with. Hence adaptations which ensure a firm gill would undoubtedly be advantageous—other things being the same—in preventing interference with the feeding process. The folding of the gill in an antero-posterior direction is also an adaptation in perfecting the feeding process, for by this means the food-collecting surface of the gill is further increased (see various figures by Ridewood, 13, pp. 242–263); moreover, greater opportunity is thereby given for effectively sieving the food-current, which has necessarily to pass more obliquely over the surface of the filaments to pass onwards into the exhalent current, thus giving the frontal cilia of the gill-filaments a better chance of capturing food-particles. It will also be seen that this folding results in the formation of secondary food-channels, thus the principal and apical filaments which occur in the troughs and crests respectively of the folds of the gills of many Lamellibranchs (see Ridewood, 13, p. 163) probably function mainly as the bearers of subsidiary food-grooves.

Along with the evolution of a more efficient food-collecting gill in Lamellibranchs there have occurred a gradual fusion of the ventral edges of the mantle lobes and a development of inhalent and exhalent siphons. It is highly probable that this fusion of the mantle lobes is primarily an adaptation of the same nature as the gill folding, that is, tending towards perfecting the mode of feeding. For in Mytilus, Glycimeris, and Ostrea, and doubtless also in many other forms, there is an attempt to limit the ingoing current to a definite area, and the effect obtained is that of limiting the area over which the heavier particles settle out of the food-stream to a part of the mantle adapted for expelling the undesirable material. In siphonate forms with the mantle fused ventrally such as the higher Eulamellibranchs, the whole of the ventral region of the mantle lobes may be utilized as a settling area from which undesirable material can be removed without interfering unduly with the normal feeding process.

IX. THE CURRENT-PRODUCING MECHANISM IN LAMELLIBRANCHS.

With regard to the cause of the main food-current in Lamellibranchs most writers are vague. Herdman and Hornell (10), however, have investigated *Margaritifera vulgaris* and state cautiously that in this species "the respiratory current is apparently due to the normal rhythmic lashing of the cilia on the large cells at the edges of the filaments; while the collection or the rejection of particles in the water seems to be the result of special action stimulated apparently by the irritation. Particles arrested by the branchial filter are caught up by the nearest cilia, which by local reversed lashing carry them outwards to the free ventral edge of the lamella."

In Crepidula it is easy to make out with certainty the direction in which the several rows of cilia are working, as the filaments—relative to those of Lamellibranchs—are large. In Nucula, Anomia, Mytilus, Glycimeris, Arca, Modiola and Pecten, I also find that it is fairly easy to make out that, as in Crepidula, the lateral cilia which lash across the length of the filaments (see Figs. 15 and 16) are the chief cause of the inhalent current, and that the "frontal" cilia which lash towards the free edge of the gill, collect the food-particles and wash them onwards towards the food-grooves at the edge of the gill (see Figs. 15 and 16).

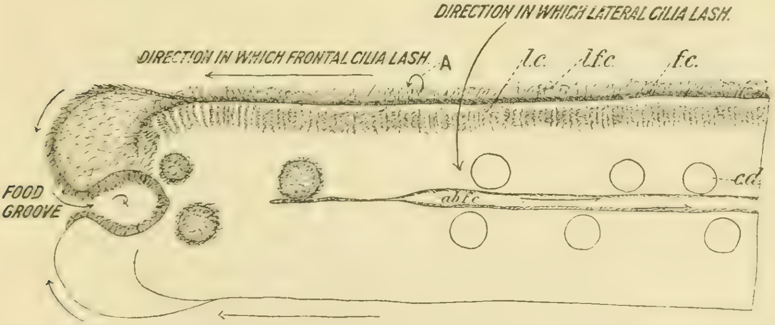
DIRECTION IN WHICH LATERAL CILIA LASH.
DIRECTION IN WHICH FRONTAL CILIA LASH.
A
l.c.
l.f.c.
f.c.
c.d.
ab.f.c.
FOOD GROOVE

FIG. 15.—Lateral view of a living filament of the left outer lamella of the gill of *Mytilus edulis*. (× about 84.)

l.c. Lateral cilia. l.f.c. Latero-frontal cilia. f.c. Frontal cilia.
ab.f.c. Ab-frontal or inner cilia. c.d. Ciliated disc.
A. Arrow indicating roughly the direction in which the latero-frontal cilia lash.

In Mytilus there are also on the "inner"* or ab-frontal side of the filament cilia which lash in a direction opposite to that of the frontal cilia; they therefore help in producing the main current as in Crepidula. These cilia doubtless also assist in keeping clean the inner surfaces of the gill-filaments. The examination of living filaments of Mytilus revealed inaccuracies in the existing figures of the gill-cilia in this form (see Peck, 14) and Ridewood (13, Fig. 11, c, p. 201). Sections were therefore prepared from well-preserved material, and a drawing of one of these made for Fig. 17 (p. 467).

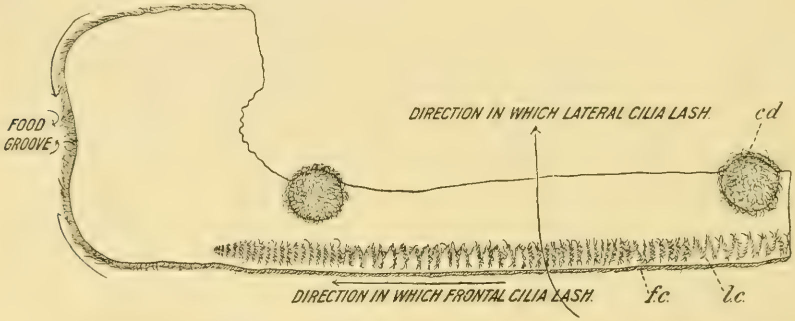
FOOD GROOVE
DIRECTION IN WHICH LATERAL CILIA LASH
cd
DIRECTION IN WHICH FRONTAL CILIA LASH
f.c.
l.c.

FIG. 16.—Lateral view of living filament of left outer lamella of gill of *Pecten maximus*. (× about 130.)
l.c. Lateral cilia. f.c. Frontal cilia. c.d. Ciliated disc.

On now comparing the ciliation in Ostrea, Tapes and Cardium, with that in the aforementioned forms, there can remain no doubt that the lateral cilia here also produce the main current by lashing across the length of the filament, while the frontal cilia collect the food-particles by lashing towards the free edge of the gill. Therefore the statements by Kellogg (9, pp. 416–423, see also 7, p. 36), and Pelseneer (12, p. 230) that the lateral cilia in Lamellibranch gill-filaments serve mainly for straining the food-particles or for interlocking the filaments require correction. There can be no doubt, however, that the lateral cilia, as in Crepidula, may help occasionally if necessary in washing particles towards the food-groove by local reversed lashing. The long cilia found at the sides of the frontal rows of cilia in many Lamellibranchs (see Ridewood's figures *passim* as latero-frontal cilia, 13) are probably true straining cilia. In Nucula, Anomia, Mytilus, Tapes, and Cardium, these are undoubtedly straining cilia. They stand out from the sides of the filament, forming a sort of grating between them, and lash relatively slowly across the length of and towards the middle of the frontal face of the filament (see Figs. 15, 17, and 18). Thus Nucula and Mytilus have four kinds of cilia, the lateral cilia producing the main current, the frontal for collecting and transporting the food, the fronto-lateral, which assist in food-collecting, and the ab-frontal or inner cilia, which help in producing the main current, in collecting food, and in cleaning the filaments.

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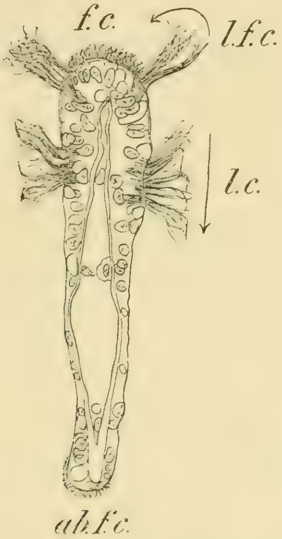
* That is, the side away from the exposed face of the gill-lamella.

Since the ciliation of the gill-filaments in all Lamellibranchs is essentially the same (see Ridewood, 13, p. 163) doubtless in all Lamellibranchs the main food and respiratory current is caused by the lateral cilia, while the collecting and transporting of food-material is done mainly by the frontal cilia, assisted by the latero-frontal cilia when these are present.



* FIG. 17.—Transverse section of gill-filament of outer left gill-lamella of *Mytilus edulis* taken near the free end of the lamella and between the ciliary junctions. (× 418.)

l.c. Lateral cilia which lash in the direction indicated by the arrow alongside.
l.f.c. Latero-frontal cilia which lash in the direction indicated by the arrow.
f.c. Frontal cilia.
ab.f.c. Ab-frontal cilia.

X. CILIATION OF THE GILL OF NUCULA.

The ciliation of the gill-plates of Nucula is, I find, essentially the same as that of the gill-filaments of Mytilus (compare Figs. 15 and 18). The lateral cilia are well developed, and, as in the other Lamellibranchs examined, produce the main current through the mantle cavity. The frontal cilia collect and lash food-particles from the tip of the outer towards the tip of the inner leaflet on both gills. The larger frontal cilia on the tips of the inner leaflets lash the collected food anteriorly towards the mouth. The latero-frontal cilia are also well developed and, as in Mytilus, stand out between the filaments, acting as strainers and lashing across the length of the filament away from the inter-filamentary spaces. These cilia are very large, and, *as in the case of all the cilia on gill-filaments, it is necessary to see them living to obtain an accurate idea of their size and function. And indeed all figures of gill-cilia ought to be corrected where necessary by comparison with the living object.* The ab-frontal cilia lash mainly towards the tip of each leaflet as indicated in Fig. 18, and besides helping in producing the main food and respiratory current, doubtless also assist in food-collecting, by lashing food-particles around the tips of either leaflet. On the outer dorsal edge of each leaflet of the gill of Nucula is a group of large cilia (see Fig. 18). Those on the inner leaflets interlock with similar cilia on the leaflets of the opposite side, while those on the outer leaflets doubtless interlock with similar cilia on the mantle. Probably these large cilia help in transferring food-particles from the dorsal to the ventral surface, but their chief function is doubtless that of effecting a junction between the right and left gills and between the gills and mantle respectively. Between the ab-frontal and lateral rows of cilia occur patches of cilia (see Fig. 18, *c. d.*) which are more numerous on

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* This section was obtained from material preserved in Bouin's Picro-formol (see 19, p. 76) and stained in borax-carmine and picro-nigrosin solutions. Picro-nigrosin after picroformol or corrosive-acetic is an excellent stain for cilia.

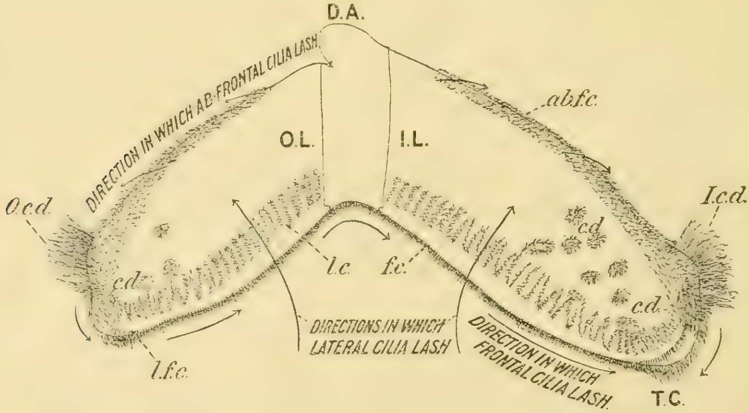
D.A.
DIRECTION IN WHICH AB-FRONTAL CILIA LASH.
ab.f.c.
O.L.
I.L.
O.c.d.
I.c.d.
c.d.
c.d.
c.d.
l.c.
f.c.
DIRECTIONS IN WHICH LATERAL CILIA LASH
DIRECTION IN WHICH FRONTAL CILIA LASH
l.f.c.
T.C.

FIG. 18.—Anterior view of a living pair of leaflets of the right gill of Nucula. (× about 65.) The leaflets anterior to the pair depicted were cut away.

ab.f.c. Ab-frontal cilia.
c.d. Patches of cilia on the inner and outer leaflets.
D.A. Dorsal surface of gill about the 30th pair of leaflets from the posterior end of gill.
f.c. Frontal cilia.
I.c.d. Cilia effecting a junction with similar cilia on the left gill.
I.L. Inner leaflet of gill.
l.c. Lateral cilia.
l.f.c. Latero-frontal cilia.
O.L. Outer leaflet of gill.
O.c.d. Cilia effecting a junction with the mantle.
T.C. Cilia which transport collected food forwards.

the inner than on the outer leaflets, and indeed are apparently often absent from the outer leaflets. These cilia arise from little spurs of tissue and have the same curious rotary motion as those which occur in patches on the gill-filaments of the Filibranchs. The action and distribution of these patches of cilia leave no doubt that they effect ciliary junctions between the leaflets in the same way as those of the Filibranchs effect junctions between filaments. There are also similar patches of larger cilia immediately below and to the side of the groups of the inter-locking cilia on the tips of each leaflet (see Fig. 18, c.d. below O.c.d. and I.c.d.). Doubtless these have also the function of interlocking the leaflets, and are similar to those occurring on the tips of the gill-filaments of Yoldia (see Kellogg, 9, Fig. 78) and *Anomia aculeata*. It is therefore evident that the gill of Nucula is undoubtedly less primitive as compared with the gill of other Lamellibranchs than has formerly been thought. A fuller investigation of this gill is being made.

XI. THE BEARING OF THE GILL CHARACTERS OF NUCULA ON THE RELATIONSHIPS OF THE PROTOBRANCHIA.

It is clear from the foregoing description that the gill of Nucula—and indeed those of Yoldia and Solenomya may be included—cannot now be regarded as being so primitive and unique as to justify the classification of the Protobranchia as a group co-equal with the Filibranchia. Ridewood has shown that the gill of *Anomia aculeata* consists on each side of two rows of filaments whose only difference from the leaflets of Nucula lies, I find, in their being narrow and filamentous instead of broad and lamellate. This obviously constitutes only a minor difference. Indeed, the occurrence of ciliated discs on the gill-lamellae of Nucula might fairly be advanced as evidence of higher specialization —along orthodox Lamellibranch lines—than occurs in the gill of *Anomia aculeata*, since the filaments of this species of Anomia appear to be without ciliated discs excepting at the tips. Further, the ciliated discs at the tips of the Anomia filaments are matched by similar ones in the gill-leaflets of Nucula, and the action and function of the various rows of cilia is, I find, the same in both animals. Moreover, the frontal cilia on the filaments of Anomia occur on the ventral surface as in Nucula, and those on the outer filaments lash in the same direction as in Nucula (see Fig. 18). Ridewood (13, p. 194) has shown that in this species of Anomia the posterior end of the gill on each side is free and that the inner filaments of each side interlock, and that the outer filaments form a junction with the mantle by means of cilia. All these features are found in the gills of Nucula (see Fig. 18).

Thus the one feature of Protobranchia regarded by Pelseneer as unique—the occurrence of gill-leaflets—is undoubtedly robbed of its glamour—and cannot now be reasonably regarded as of such great taxonomic value as formerly. Another supposedly unique feature of the Protobranchs, namely, the absence of a subdivision of the mantle cavity (see Sedgwick 15, p. 345), must be abandoned, for Drew has already shown that in Yoldia (11, p. 14) there is a subdivision of the mantle cavity into inhalent and exhalent chambers, as is here described for Nucula, and as will no doubt be found in all the Protobranchs. With regard to the other primitive or special features of Protobranchs, such as the occurrence of distinct pleural ganglia, a plantar surface to the foot, free communication between the cavities of the gonad, pericardium, and kidneys, and other features—with regard to these, Pelseneer has already shown (12, *passim*) that they are matched in some adult members of the Filibranchs with the exception of separate pleural ganglia, which at present are only known in the developmental stages of other forms (as Modiolarca, Dreissensia, etc. See Pelseneer 12, p. 234). It is therefore clear that the Protobranchs cannot now be classified as a group equivalent to the Filibranchs. We must therefore be prepared to degrade —or rather elevate—the Protobranchia to a subordinate position in the Filibranchia of Pelseneer, or in the Eleutherorhabda of Ridewood. It is a matter of much interest that Palaeontologists (16, p. 359) should already have classified together the Protobranchia and the remainder of the Filibranchs into the order of Prionodesmacea, whose diagnosis is concerned mainly with shell characters. As we may now take for granted that Lamellibranchs have evolved mainly on the principle of perfecting the gill as a feeding organ, it is clear—from the closely similar results attained by Palaeontologists and modern zoologists—that there is a close correlation between shell characters and gill characters. Whether the shell characters are capable of any functional explanation, similar to that of the gill characters, my knowledge of the group does not yet enable me to say. It is probable that such an explanation may now be possible.

XII. A COMPARISON OF THE MODE OF FEEDING IN LAMELLIBRANCHS AND CREPIDULA.

In Lamellibranchs, as in Crepidula, it has been noted that there is an arrangement whereby an automatic selection of the heavier particles takes place just inside the inhalent chamber. Thus the forwardly directed stream in the inhalent chamber in Crepidula is equivalent to that caused by the ciliated path on the mantle of Lamellibranchs; the purpose of the stream in both animals being that of expelling undesirable material from the inhalent chamber. There is this difference, however, that Crepidula, unlike the oyster, has the option of ingesting the automatically selected heavier particles. On the other hand, in the oyster and other Lamellibranchs the fringes of tentacles on the edge of the mantle form a coarse sieve by interlacing at the entrance to the mantle cavity, and in this way prevent the entrance of coarse particles; it is possible, however, that the particles collected on the mantle in Lamellibranchs might be picked up by the gill and conveyed to the mouth, as probably happens in the posterior region of the inhalent chamber of the oyster and the scallop. Both animals have still another opportunity for selecting their food-material, namely, by refusing the food-masses which are brought by the gills to the mouth. It has been observed that both animals do at times refuse such food, so that selection of food-material is undoubtedly exercised in this way. From my preparations of the gut contents of these two animals, I received the impression that those of the oyster were the finer, but as I have examined comparatively few specimens, it is doubtful whether that observation has any significance. It would be necessary to examine and compare a larger number of individuals to obtain a significant result. The fine food-particles are collected on the gill in both Crepidula and Lamellibranchs, and conveyed along food-grooves to the mouth, but Crepidula may be regarded as having gained an advantage over Lamellibranchs by closing in its food-groove, and thus ensuring the capture of the food. If disturbed while feeding an oyster would be much more liable to lose its food than Crepidula.

There is, however, an interesting difference in the position of the lateral cilia on the filaments in Crepidula and Lamellibranchs. In Crepidula these cilia are nearer the exhalent chamber (see Fig. 6, l.c., p. 452), while in Lamellibranchs they are nearer the inhalent chamber (see Fig. 18, l.c., p. 468). An explanation of these phenomena will probably be offered when more Gastropod gills have been studied.

It will now be apparent how remarkably similar Crepidula, its allies, and Lamellibranchs are in the details of their modes of feeding. The closeness of the resemblances they offer may fairly be regarded as an expression of the similar tendencies they have derived from their common origin.

XIII. THE MODE OF FEEDING IN THE ALLIES OF CREPIDULA.

The nearest allies of Crepidula doubtless all feed as Crepidula itself does. Such a deduction may fairly be drawn at once from the similarity in the mode of life of those animals and the general similarity of their organs in the region of the mantle cavity. I have examined *Calyptraea chinensis* alive, and find that it feeds in exactly the same way as does Crepidula, collecting food both in its epipodial food-groove and in a food-pouch.

Capulus hungaricus exhibits an interesting variation of the same manner of taking food. In this animal there is no epipodium nor food-pouch. But instead of the former the lips have become elongated in the form of a grooved proboscis, which appears to be held along the right side of the animal to collect the food-particles from the tips of the gills when the animal is feeding. The forwardly-directed stream is present on the edge of the mantle in the inhalent chamber, but the stream is relatively weak. There is an outgrowth of the foot between the propodium and the "neck" region, known as the "operculum," which appears to be used partly for side-tracking the food-current into the exhalent stream when the animal is not feeding, but I have not yet had the opportunity for investigating Capulus fully, and so must defer a detailed account until later.

The Hipponycidae are so similar in structure to the Capulidae as to have been placed with them at one time in the same Order, and as they live a sedentary life, it is almost certain that they will be found to feed in some similar manner to that of Capulus. There is, therefore, little doubt that all the Calyptraeidae feed in the same way as Crepidula, and that the Capulidae feed in a similar manner: thus there is good reason for suspecting that all sedentary Pectinibranchs may obtain their food in the same or in a similar manner.

XIV. THE CURRENT-PRODUCING MECHANISM IN OTHER GASTROPODS.

After seeing the gills of Crepidula, Calyptraea, and Capulus, and especially the latter, whose gill is very similar to that of most Gastropods, I was stimulated to examine all the sedentary forms to be had. But, on seeing Pelseneer's figures of sections of the gills of some Aspidobranchs (17, Figs. 99 to 104), I was induced to examine all the Gastropods available. It was found that in all the forms examined, namely, Fissurella, Haliotis, Calliostoma, Gibbula, Murex, Purpura, Nassa, Buccinum—in all these—the gill-filaments are ciliated in essentially the same way as those of Crepidula. There are generally present lateral, frontal and ab-frontal cilia, and the gill-filaments, or rather gill-leaflets, closely resemble those of the Protobranchs. The lateral cilia in all the forms examined produce the main current in the mantle cavity. The occurrence of frontal and ab-frontal cilia in all these forms is a matter of much interest. In all cases these cilia collect plankton from the ingoing current, but whether such collected food is eaten I am not yet able to say. It seems probable that all these forms may be found to feed partly on plankton. A research into this matter is being made. In some cases (namely, Fissurella and Buccinum) the gill undoubtedly divides the mantle cavity into inhalent and exhalent chambers as occurs in Crepidula and its allies. At the tips of the filaments in all these forms there are interlocking cilia similar to those at the tips of the gill-leaflets of Nucula. These cilia doubtless serve to effect a junction between the gill and the opposite wall of the mantle. Thus there can be no doubt that most Gastropods on further investigation will be shown to have the mantle cavity divided by the gill into two chambers.

A point of some interest presents itself at once on comparing the gill-filaments or gill-leaflets of the Aspidobranchs and many Pectinibranchs with the gill-filaments of Crepidula and Calyptraea, namely, that the gill-leaflets of the former bear the same relation to the filaments of the latter that the gill-leaflets of Nucula bear to the gill-filaments of the Filibranchs. Thus the Pectinibranchs already present the same range of gill-features that I propose should be united in the Filibranchiate Lamellibranchs. It may here be remarked that the similarity in the structure and function of the gills in Gastropods and Lamellibranchs shown by the foregoing observations, emphasizes that close relationship between these groups, which Pelseneer has already pointed out (17).

A cursory examination of the gills of Chitons indicates that rows of lateral cilia on the gill-leaflets produce the main current through the mantle cavity in a manner similar to that in Gastropods and Lamellibranchs.

XV. SIGNIFICANCE OF CHAIN FORMATION IN THE MODE OF FEEDING OF CREPIDULA.

It is well known that Crepidula has the curious habit of forming long chains by one individual settling on the back of another; as many as fourteen individuals may be found holding together in such a manner, and usually there is a gradation in size from the largest at the bottom to the smallest at the top.* Each individual does not sit in the *middle* of the back of the one immediately below, but with the right anterior edge of the shell touching the same part of the shell next below. As a result each animal topples over a little to the right of the one below it, so that the chains really form spirals (see Fig. 19). This arrangement has some relation to the mode of feeding, for by the toppling over to the right each individual is given a maximum area of water to draw on from the left side for its food-current, which it will be remembered is drawn in at the left. Moreover, the approximation of the right sides of all the individuals of a chain results in a combination of the exhalent currents, which must give excellent results in removing effete products from the chain. The combined exhalent currents will doubtless also assist the smaller individuals in the chain by reducing the pressure of the water in the region of the exhalent aperture, and thus enabling them to pass a greater volume of food-bearing water through their mantle cavities than they otherwise could.

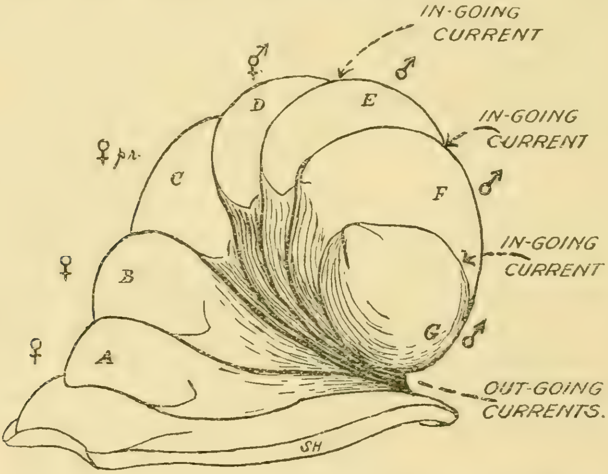

FIG. 19.—Postero-lateral view of a chain of seven individuals of Crepidula to show the separate ingoing and the combined outgoing current of all the individuals in the chain. (Natural size.)

These advantages of chain formation are to be added to those already noted (2, p. 479), and it may be remarked that the copulation of the smaller with the larger individuals there suggested as probable has now been observed a good many times, and contrary to what Prof. Conklin has suggested (1, p. 16), several times by the same individuals, and by individuals separated from each other by one or two of their fellows. These observations, however, are still being carried on.

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* See (2) pp. 469–80 for a fuller description of chain phenomena.

In connection with the feeding habits of whole chains, an interesting adaptation has many times been observed: when a number of chains have established themselves on a surface of limited extent, as on a valve of an oyster-shell, the chains are to be found with their anterior ends towards the edge of the oyster-shell and their posterior ends all converging on the middle. Thus the animals are again found to be making the best use of the space at their disposal for ensuring an equally good respiratory and food-current to each member of the group.

From a consideration of the mode of feeding of Crepidula its habits are easily explained, and it is now easy to understand why all individuals but small ones run a great risk of death if they become disenchained, or detached from their surface of attachment. A detached individual with its mantle cavity exposed is unable to produce an effective respiratory and food-current, which along with some unknown cause which gives rise to the general discomfort usually exhibited eventually results in death. Moreover, if a new surface of attachment is offered, it is necessary for the animal to be able to fit its shell fairly well to it in order to have a chance of living. If, however, an animal be offered a surface to which it is able to accommodate its shell, I find that it is usually able to accept it, especially if the surface offered is smooth.

XVI. THE MANDIBLES OF CREPIDULA.

The location of the mandibles of Crepidula appears to have given so much difficulty that even Troschel confesses (18), "Die beiden Kiefer habe ich nur einmal bei *Crepidula fornicata* gefunden. Sie Können also leicht übersehen werden. Der eine Fund beweist dass sie vorhanden sind, und dass die Meinung diese Familie sei kieferlos welcher ich lange Zeit gehuldigt hatte, irrthumlich war."

During the foregoing research, however, a clue was given from the mode of feeding as to the probable position of the mandibles, so that it was possible to make a preparation to demonstrate them at once. As Crepidula in eating takes food into the mouth between the roof of the mouth and the dorsal surface of the radula, one would expect to find the mandibles in the dorsal wall of the buccal cavity. If this region be exposed after dissecting out the radula and its muscular apparatus, the mandibles are to be found lying transversely on a prominence near the mid-dorsal line and just behind the mid-dorsal anterior edge of the buccal cavity as in Fig. 20. They are easily found by following the above directions after soaking the head region in glycerine.

Troschel describes the mandibles and gives a drawing of them in the work cited. They are very small, being about ·7 mm. long and ·16 mm. wide in the widest part.

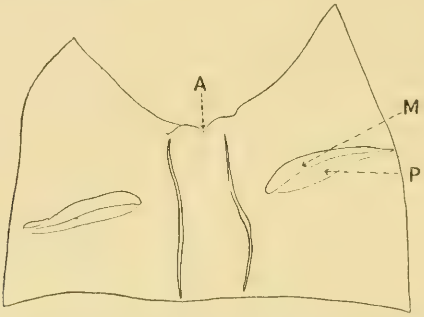

Fig. 20.—Ventral view of the roof of the mouth of Crepidula. (× 25.)

A. Middle part of anterior edge of the roof of the mouth.
M. Mandible.
P. Prominence on which the mandible is situated.

SUMMARY.

The gut-contents of Crepidula and the English oyster are similar with regard to skeletal remains, and the commonest diatoms found in both animals are the same.

Crepidula is a marine Pectinibranch which settles down at an early age to a sedentary life.

Crepidula feeds in the same way, in principle, as the oyster, i.e. a food-current of water is set up in the mantle cavity, while between the entrance and the exit of the current the pectinate gill acts as a food-sieve. The food-particles arrested in the inhalent chamber reach the mouth in one of two ways: the fine particles by way of a food-groove on the right side of the body, the coarse particles by way of a food-pouch placed in front of the mouth.

The radula is used for grasping the food-masses and conveying them into the mouth; its function has therefore changed from a rasping to a grasping organ, hence adaptational developments of the radula may be expected to occur in the allies of Crepidula.

The mode of feeding may be easily observed in detail by inducing animals to fix on glass and feeding them with carmine granules suspended in methylene blue solution in sea water.

The main food-current is caused chiefly by rows of cilia, the lateral cilia, on the anterior and posterior faces of the gill-filaments: the food-streams are caused by rows of cilia on the dorsal and ventral faces of the gills, by cilia on the dorsal surface of the animal, and by cilia on the inside of the mantle.

The gill of Crepidula, like that of Lamellibranchs, is at the same time a respiratory organ, a water-pump and a food-sieve.

The food-streams of Crepidula are comparable to those of Lamellibranchs.

A partial selection of the coarser food-particles is effected in the oyster—and Lamellibranchs generally—in the same way in principle as in Crepidula.

There are special morphological arrangements in Mytilus and Cardium to assist in the automatic selection of the finer food-particles.

The main food and respiratory stream in Lamellibranchs is caused by the "lateral" cilia on the gill-filaments, while the collection and transportation of food is effected mainly by the frontal cilia of the filaments. The latero-frontal cilia in Nucula, Anomia, Mytilus, Tapes, and Cardium, and therefore probably in all the Lamellibranchs in which they occur, are true straining cilia.

The gill-leaflets of Nucula and most Protobranchia possess similar cilia having a similar function to those on the gills of higher Lamellibranchs, and those of *Nucula nucleus* have also ciliated discs.

The gill of Nucula divides the mantle cavity into infra- and suprabranchial chambers, and the ventral surface of the gill is used for food-collection in the same way as in higher Lamellibranchs. Thus the gill of Nucula is essentially similar to that of some Filibranchs—for example, some species of Anomia and Dimya.

Hence the Protobranchia cannot now be considered as a group co-equal with the Filibranchia, and should be elevated to a sub-division of the Filibranchia.

Evolution in Lamellibranchs, which has occurred mainly on the principle of folding and consolidating the gill-filaments, comprises a series of adaptations tending towards a more perfect mode of feeding.

Calyptraea chinensis feeds in exactly the same way as Crepidula, and *Capulus hungaricus* feeds in a similar way.

Doubtless, therefore, all the Calyptraeidae, all the Capulidae, and there is reason to suspect that all sedentary Pectinibranchs, feed in the same or in a similar manner.

Most Gastropods have gill-filaments essentially the same in structure and function as those of Lamellibranchs, i.e. lateral cilia occur generally and produce the main current in the mantle cavity; frontal and ab-frontal cilia are found, and these collect food-particles from the ingoing current. In many Gastropods, and probably in most branchiate forms, the mantle cavity is divided by the gill into inhalent and exhalent chambers.

The manner of chaining in Crepidula is adapted to securing a good food and respiratory current.

The mandibles in Crepidula are to be found just behind and a little to either side of the middle of the anterior border of the roof of the mouth.

The author wishes here to express his thanks and indebtedness to the Government Grant Committee for a grant out of which some of the expenses of the foregoing work were defrayed. He is also grateful to Dr. Allen for useful criticism.

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On the Precipitation of Calcium Carbonate in the Sea by Marine Bacteria, and on the Action of Denitrifying Bacteria in Tropical and Temperate Seas.

By

G. Harold Drew.

With Two Figures in the Text.

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INTRODUCTION.

THE investigations in the American Tropics described in this paper were made during the summers of 1911 and 1912 under the auspices of the Carnegie Institution of Washington: the work was made possible by the invaluable help and kindness of Dr. Alfred G. Mayer, Director of the Department of Marine Biology. The investigations in Temperate waters were made from the Plymouth Laboratory of the Marine Biological Association of the United Kingdom, and my thanks are due to the Council and Director of the Association for giving me every facility for the work.

Originally the primary object of the investigations was to make a study of the action of marine denitrifying bacteria in Tropical and Temperate seas. The discovery during the course of the experiments that these denitrifying bacteria also possess the power of precipitating Calcium carbonate from soluble Calcium salts present in sea-water has, perhaps, by its geological significance, somewhat overshadowed the interest of the primary object of the work.

The main contentions raised in this paper are—

(1) That in the seas of the American tropics bacteria exist which are actively precipitating Calcium carbonate from the Calcium salts present in solution in sea-water. It is suggested that this bacterial action has been a very considerable factor in the formation of chalk and many other varieties of sedimentary rock, chiefly, or in part, composed of Calcium carbonate. It is also contended that the vast deposits of chalky mud now being formed to the West of the Bahamas, and in the neighbourhood of some of the Florida Keys, are being precipitated by bacterial agency, and that a similar process plays an important part in the cementation of fragments of coral and other detritus into compact coralline rock.

(2) That the destruction of Nitrates by bacterial action in the seas of the American Tropics is far in excess of that occurring in Temperate waters. Hence an explanation is afforded of the relative scarcity of plant life (and consequently of animal life) in Tropical as compared to Temperate seas, in accordance with the terms of Brandt's (2) hypothesis.

Preliminary notes on this work have already been published in the Tortugas Laboratory Reports for 1911 and 1912 (4 and 6) and in the Journal of the Marine Biological Association (5). The chronological sequence of the investigations will be followed in the account given here of the experimental work.

GENERAL CONSIDERATIONS AND PREVIOUS WORK.

It is generally conceded that the plankton of Tropical and sub-Tropical seas is far less in quantity than that found in colder waters.*

The zoo-plankton depends ultimately for its food on the phyto-plankton, hence any factor limiting the growth of the phyto-plankton, which was capable of exercising its influence in Tropical and not in Temperate or Arctic waters, might offer an explanation of this phenomenon. It has been shown by various investigators that this factor is not temperature, light, or salinity, and it has been suggested that the explanation may lie in the relative deficiency in Tropical seas of the Nitrates or nitrogenous compounds which are so essential for all plant life. A matter of common observation in support of this view is the remarkable scarcity of Algal growth in the shallow waters of Tropical shores as compared with that in Temperate regions, and the fact that in the Tropics, wherever sewage or other nitrogenous waste is poured into the sea, a free growth of Algae is found.

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* For the most recent work, and full discussion of this subject, see "The Depths of the Ocean," by Murray and Hjort (13), p. 366 *et seq.*, London, 1912.

At present no really reliable and accurate chemical method of estimating the combined Nitrogen in sea-water exists, hence the above theory cannot be directly put to the test. On the other hand, the existence of denitrifying bacteria in Temperate waters has long been known, and it would seem a fair deduction that should this bacterial destruction of Nitrates take place with greater intensity and completeness in Tropical than Temperate waters, an explanation of the relative scarcity of phyto-plankton in the former would be offered. This suggestion was first made by Brandt (2) in 1901, and is universally known as "Brandt's hypothesis." He enunciated it as follows :—

"If the denitrifying bacteria of the sea, like the closely-investigated denitrifying bacteria of the land, develop a strongly disturbing activity at higher temperatures, only a relatively small production (of phyto-plankton) would take place in the warm seas in spite of much more favourable conditions, according to the law of the minimum, owing to the great disturbance amongst the indispensable food substance; whilst, in the cold seas, more nitrogen compounds would be at the disposal of the producers owing to the retardation or suppression of the disturbing process." (*From the published English translation.*)

The presence of denitrifying bacteria has been demonstrated in Kiel Bay by Baur (1), along the Dutch coast by Gran (9), in the open waters of the North Sea and Baltic by Feitel (7) and Brandt (2 and 3), and in 1909 I identified several of the species described by Gran in samples of water obtained from the Western part of the English Channel. All these denitrifying species have a higher temperature optimum than that of their natural environment, and this is obviously a point strongly in favour of Brandt's hypothesis.

The chief difficulty in the way of putting the hypothesis directly to proof lies in the fact that at present no accurate method of determining the Nitrate contents of sea-water exists, and hence it is impossible to correlate quantitative plankton observations with direct analysis of the amount of combined Nitrogen present in sea-water in different localities. Much valuable work on this subject has been done by Raben (15), but he states that his error in control experiments averages over 30%. An exhaustive study (as yet unpublished) of all the methods of estimating combined Nitrogen in sea-water, as given by various investigators, has been made by Mr. D. J. Matthews, Hydrographer to the Marine Biological Association of the United Kingdom, and he has come to the conclusion that the limits of error in all these methods are so large as to make them quite unreliable. Since chemical methods are at present inadequate to give evidence on this hypothetical deficiency of Nitrates in warmer seas, it seemed of interest to investigate the distribution and relative activity of denitrifying bacteria in Tropical waters in comparison to those found in Temperate seas, and it was with this primary object that the present work was undertaken.

The previous researches most closely related to these investigations are those of Gran (9), who isolated a number of species of denitrifying bacteria from the inshore waters of the Dutch coast. He made use of solutions of Nitrates, Nitrites, or Ammonium salts as the sole source of Nitrogen in his culture media, which contained only a dilute solution of Calcium malate as organic nutrient material for the bacteria. He classifies the bacteria into four groups according to their reactions in pure cultures towards Nitrates or Nitrites:—

(1) Those which reduce Nitrates and Nitrites to free Nitrogen without any Ammonia formation.

(2) Those which readily reduce Nitrates to Nitrites. The Nitrite disappears slowly without perceptible formation of free Nitrogen, and some Ammonia is formed.

(3) Those which cannot reduce Nitrates to Nitrites, but which are capable of slowly removing the Nitrate without perceptible formation of free Nitrogen. Though the Nitrites are not reduced, yet they can serve as the sole source of Nitrogen for the growth of the bacteria.

(4) Those which cannot reduce, and are not capable of assimilating either Nitrates or Nitrites, but will flourish when Ammonium salts are present.

In investigations on samples of water taken in the English Channel some ten miles off Plymouth, I was able to recognize species belonging to the second group of Gran's classification, but could not detect the presence of species belonging to any of the other groups, and it would seem probable that these other groups are chiefly composed of littoral forms.

In fluid culture media inoculated with samples of sea-water and kept at a temperature of 28° C., Gran found that the formation of Nitrite was detectable in from one to two days, and that eventually all the Nitrate and Nitrite was destroyed in the majority of cases, especially if the cultures were reinoculated at intervals. In my experiments I was able to obtain similar results in cultures kept at 30° C. after eight days; in cultures kept at 15° C. the first formation of Nitrite was detectable in from five to six days, but denitrification never proceeded beyond this stage.

Baur (1) showed that the optimum temperature for growth and denitrification of the species described by him lay between 20° C. and 25° C., when the bacteria were grown in fluid culture media containing Peptone.

The most important work on the distribution of marine bacteria is that of Fischer (8) in 1886, 1889, and 1893, but he does not enter into the chemical activities of the species found, so that the observations do not throw much direct light on problems of the metabolism of the sea. The variations in the number of bacteria found in different surface samples from positions in mid-ocean are somewhat surprising and difficult to account for. Deeper samples were taken by means of a water-bottle made of brass, but in view of the now well-known bactericidal action of metals, and of copper in particular, I do not consider that any great value can be attached to these observations. With the exception of Fischer's work, little seems to have been published on the general distribution of marine bacteria.

A point that has not yet been considered is the origin of the Nitrate supply in the sea. Nitrates are absorbed by diatoms and the phytoplankton in general, and are presumably built up into complex nitrogenous compounds within the plant. If these compounds, on the death of the plant, are broken up and the Nitrogen again rendered available for use in the form of Nitrates, a series of reactions must be gone through which may well be performed by bacterial agency, and this also applies to the waste nitrogenous products of animal metabolism. In addition, it has been shown that Nitrates are actually decomposed by the denitrifying bacteria, which would thus tend to keep the Nitrate concentration down to the level necessary for their own existence, and would come into competition for this essential with other forms of plant life. If the bacteria are successful in decomposing Nitrates to the extent of entirely removing the Nitrogen from all chemical combination, as seems probable from the experiments in cultures, it follows that there must be some source of Nitrates in order that the concentration in the sea may remain constant. The existence of nitrifying bacteria, which are capable of absorbing and combining with the free Nitrogen of the air and eventually giving rise to Nitrates, has been shown by Keding (10) and Keutner (11), but these have so far only been found on the bottom close to shore, or apparently living in symbiosis with algae or plankton organisms. Similarly, Thomsen (16) has demonstrated the presence on the bottom of inshore waters of bacteria which are capable of forming Nitrites from Ammonium salts, and others which can convert Nitrites into Nitrates. It would seem possible that similar bacteria having a nitrifying action remain to be discovered in the open sea.

The precipitation of Calcium carbonate in the sea by bacterial agency is apparently a line of investigation that has not previously been suggested or followed. Both Baur (1) and Gran (9) made use of

Calcium salts in their culture solutions in order to obviate the great increase in alkalinity that resulted if Potassium or Sodium salts were used, but they have not called attention to, or apparently realized, the probable significance of this precipitation of Calcium carbonate by bacterial agency as an important factor in the formation of various sedimentary calcareous rocks in Tropical seas.

The subject of the precipitation of Calcium carbonate in sea-water has been dealt with by Murray and Irvine (14) in 1889, and again by Murray and Hjort (13) in 1912, and they ascribe the precipitation to the interaction of Ammonium carbonate, derived as an ultimate product of the decomposition of nitrogenous organic matter, with the Calcium sulphate present in sea-water, according to the equation

$$(NH_4)_2\,CO_3 + CaSO_4 = CaCO_3 + (NH_4)_2\,SO_4.$$

Expressed in the terms of the Ionic Hypothesis, this reaction can be explained by the statement that $CaCO_3$ must be precipitated when the product of the concentration of its ions $Ca^{\cdot\cdot}$ and CO_3'' exceeds a certain limit; an increase in the concentration of CO_3'' ions is produced by the advent of $(NH_4)_2CO_3$, which is partially ionized into $NH_4^{\cdot}$ and CO_3'', and hence the product of the concentrations of $Ca^{\cdot\cdot}$ and CO_3'' ions is increased, and $CaCO_3$ is thrown out of solution.

Though this reaction has been shown conclusively to occur under experimental conditions, where nitrogenous organic matter has been allowed to putrefy for some time in sea-water, yet it is obvious that its effect must be purely local, and must be confined to the immediate neighbourhood of the decaying organic body, which gives rise to the formation of $(NH_4)_2\,CO_3$.

In this paper the precipitation of $CaCO_3$ in an unorganized state alone is dealt with. The formation of the calcareous skeletons, tests, and shells of animals, and the skeletons and platelets of algae, which play an immensely important part in the constitution of marine bottom deposits, is beyond the scope of these investigations.

DESCRIPTION OF APPARATUS.

In 1911 the apparatus at my disposal was of a somewhat primitive nature, as it is difficult when on the first expedition in a new field of work to know beforehand exactly what gear will be necessary. In 1912 a more complete outfit was available, and the Carnegie Institute yacht *Anton Dohrn* was especially fitted for my requirements.

For deep-sea work the motor trawl winch was modified so as to carry fine sounding wire, and a derrick was rigged aft, projecting over the stern of the boat, over which the wire was led. The motor winch is sunk below the level of the deck, an arrangement which is to be greatly commended, as it can be covered over with hatches when not in use, and so affords great economy of deck space, and also has the advantage of bringing the weight of the winch nearer the water-line, and avoiding the unstability that may be caused when a heavy winch is fixed on deck.

The sounding wire was 2·2 mm. in diameter, and consisted of four strands of eight wires each, made of high tensile steel; the breaking strain was given at 400 lbs., but in practice I have no hesitation in saying that it far exceeded this figure. The wire was very difficult to kink, and did not show any tendency to untwist or permanently stretch under a tension of about 350 lbs.; it proved in every way satisfactory, and was supplied by Messrs. Bullivant and Co., of London.

For measuring the length of wire run out, one of the fathom measuring sheaves as made by the Telegraph Construction and Maintenance Co., of London, was used. This consisted of a sheave containing a steel wheel about 12 inches in diameter, grooved for and made especially to fit the wire; the length of wire run out is measured by the number of turns of the wheel indicated by a dial on the side of the sheave. The dial has two hands showing fathoms and hundreds of fathoms, the hands revolve backwards on winding in the wire, and so again register zero when the sounding is completed. The axle of the wheel revolves on simple bearings, so the slight inaccuracy unavoidable if ball bearings are employed is prevented.

Samples of the bottom were obtained with one of the "snapper rods," disengaging a 30-lb. iron weight on touching the bottom, also supplied by the Telegraph Construction and Maintenance Co. This consisted of two brass jaws closed by a strong spring, and kept apart by a trigger; on touching bottom the trigger was released and the jaws closed on a sample of the bottom; at the same time the 30-lb. weight, which was only held in position by the tension of its own weight, was disengaged as soon as the tension was relieved on touching bottom, and so was left behind as the wire was reeled in.

In order to tell the depth at which bottom was sounded, the wire was led through a pulley connected with a spring balance, which thus registered the tension of the wire. On touching the bottom the decrease in tension, due to the release of the weight, was shown on the dial of the balance. This arrangement was not satisfactory in rough weather, as the rolling of the yacht caused such varying tensions on the wire that it was not always possible to tell the exact depth at which the weight was disengaged.

For obtaining samples of water for bacterial analysis a special water-bottle was designed for me by Mr. D. J. Matthews. This apparatus is described in detail by Mr. Matthews in the present number of the "Journal of the Marine Biological Association of the United Kingdom," so only a brief account of it will be given here (see p. 525).

The apparatus employed by previous workers for obtaining samples of water from the deep sea for bacteriological examination has either consisted of some sort of water-bottle made of metal, or else of exhausted glass bulbs, with a neck drawn out into a capillary tube, which could be broken off at the depth from which a sample was desired. The use of exhausted glass bulbs presents considerable difficulties for depths as great as 800 fathoms: the bulbs must be strong and very thoroughly annealed, as otherwise the slight shock caused by breaking the capillary neck is liable under the great pressure to make the bulb fly into small fragments: another great disadvantage is the strong probability that the sudden reduction in pressure to which the water is exposed, as it enters the bulb, would immediately kill any bacteria in the water. The employment of a metal water-bottle seemed undesirable in view of the bactericidal action of metals: in order to settle this point some test experiments were made with various metals to see if a suitable one could be found. 100 c.c. of water from the Laboratory tanks at Plymouth, diluted 1 in 100 with sterile sea-water, was exposed for six hours to the action of about two square inches of various metals, with the following results:—

Metal.	Numbers of plates.	Number of colonies of bacteria developing from 1 c.c. after plating on Peptone Agar. Counted after 10 days.
Aluminium bronze . .	1	0
"	2	0
"	3	0
Pure copper foil . .	1	1
"	2	0
"	3	0
Brass	1	0
"	2	0
"	3	1
Pure nickel . . .	1	17
"	2	12
"	3	8
Silver (coins) . . .	1	3
"	2	2
"	3	4
Control experiment .	1	512
"	2	560
"	3	480

It is thus obvious that none of these metals are suitable for the work, and probably the only metal that could be used would be Platinum, which would be prohibitive on account of the expense.

In order to overcome these difficulties, a water-bottle on a new principle was designed for me by Mr. Matthews.

The container of the bottle consisted of a strong glass cylinder holding about 250 c.c.: this was closed at each end by thick rubber washers, through the centre of which a short piece of thin-walled rubber tubing passed, the tubing being sealed at the end within the cylinder. The washers were fixed in metal plates sliding along the guide bars of the skeleton frame in which the glass cylinder was fixed, and by sending down two messengers along the sounding wire the cylinder could first be opened at both ends and then closed at any required depth. The whole apparatus was first sterilized by steaming in a "Koch," and then the cylinder was completely filled with 95% Alcohol: the washers were kept tight on the ends of the cylinder by strong springs so that no leakage occurred. When the apparatus had been lowered to the required depth, the first messenger was sent down, this, by hitting a lever, opened the cylinder at both ends, and the alcohol, being of lower specific gravity than sea-water, diffuses out almost instantaneously, causing an upward flow of water through the cylinder. On sending down the second messenger the cylinder, with its sample of water, was tightly closed at each end by the rubber washers.

The washers, with their attached pieces of thin rubber tubing, had sufficient capability of bulging inwards to allow for the contraction of the Alcohol, due to the low temperature at any considerable depth, and to its compressibility being greater than that of sea-water, and similarly the expansion of the sample of water, as the apparatus was hauled up, was compensated for by the partial collapsing of the thin-walled rubber tubing. It is obvious that even had a slight amount of leakage occurred, a leakage inwards during the descent of the apparatus would not vitiate the results, as bacteria would promptly be killed in the 95% Alcohol, and similarly on hauling up, the leakage, if any, would be outwards, due to the expansion of the sample through the regularly increasing temperature and decreasing pressure, so that the sample would not be contaminated by any of the surface layers through which it was hauled. There was, however, no reason to suppose that any leakage occurred, and it appears that the expansibility of the rubber washers and tubing was sufficient to allow for the small changes in bulk of the fluids within the cylinder. After the first sterilization by steaming, the action of the Alcohol was relied on for sterilization between successive samples, and both experimentally and in practice this method was found to be absolutely safe, as all the marine bacteria are very readily killed by Alcohol, and they do not form resistant spores.

After the collection of a sample it was siphoned off into a sterilized glass bottle by means of a sterilized length of rubber tubing: this method was considered preferable to any arrangement of taps leading from the collecting cylinder, owing to the difficulties of cleaning and sterilization which would be involved. Part of the sample was also siphoned off into bottles, which were returned to Plymouth for analysis for salinity: these bottles had previously been thoroughly washed and rinsed with several changes of distilled water, and then dried in an oven; they were closed with rubber stoppers.

It was found in practice that this design of water-bottle worked extremely well and gave very little trouble; it is to be noted that the sample of water collected is kept only in contact with rubber and glass throughout, so that the bactericidal action of metal is avoided.

Surface samples of water were taken in wide-mouthed stoppered bottles, holding about twelve ounces; the samples were always taken from the bows of the boat when moving ahead, in order to avoid any possible contamination from the sides of the boat.

Some samples from depths up to 80 fathoms were collected off the Tortugas in 1911 in retort-shaped glass flasks of about 300 c.c. capacity, with narrow, recurved, long-drawn-out necks. These were sterilized, exhausted, and sealed; they were then lowered in an apparatus in which the extremity of the neck could be broken off at any desired depth by sending a messenger down the sounding wire, when the flasks became completely filled with water. After hauling up, a little water was shaken from the neck, and it was then sealed with the blowpipe. By this method risk of contamination from more superficial layers of water as the apparatus is drawn up is avoided, since the changes in pressure and temperature as it ascends tend to cause a continuous outflow through the narrow neck until the surface is reached.

A somewhat similar apparatus was used for obtaining deep samples from the station 70 miles west of Ushant, but the glass bulbs were smaller, and the tube leading from them was bent at right angles to itself. Considerable difficulty was caused by the breaking of the tube owing to the force of the inrushing stream of water impinging on the wall where it was bent at right angles.

If this form of apparatus is used, all sharp angles in the inlet tube should be avoided, and it should be so arranged that the inrushing stream of water spreads itself in a fan-shaped manner over the sides of the bulb, but I do not consider that any form of exhausted glass flask is suitable even for depths as small as 80 fathoms.

In Jamaica no apparatus for obtaining deep samples was available, so the primitive method of lowering a sterilized stoppered bottle with a string tied to the stopper was employed. At the required depth the stopper was pulled out until the bottle was nearly full and then allowed to fall back in place. This method can only be used for very shallow depths owing to the pressure of the water at greater depths making it impossible to withdraw the stopper.

Temperature records were obtained in the Bahamas by means of deep-sea reversing thermometers, specially made by Messrs. Negretti and Zambra, of London. They were tested up to a pressure of three tons to the square inch at the National Physical Laboratory at Teddington, and a table of temperature corrections was furnished for each instrument by the same Institution. These reversing thermometers differ from ordinary thermometers in having a constriction and S-shaped dilatation immediately above the main bulb, and in having a somewhat large secondary bulb at the upper end of the stem. The graduations are reversed, so that the lowest temperature is marked near the top of the capillary portion. On turning the thermometer upside down, the mercury thread breaks at the constriction, and fills the small bulb at the end of the capillary and also part of the capillary itself. The thermometer is read in the reversed position, and when certain corrections have been applied, the reading records the temperature at which the thermometer was reversed. The effect of the pressure of the water is avoided by having the thermometer sealed in an outer glass case. The lower end of this case is partially filled with mercury in which the bulb of the thermometer is immersed, thus allowing for rapid conduction of heat between the mercury in the thermometer bulb and the surrounding water. An auxiliary thermometer was sealed up in the same outer case as the reverser, so that the temperature at which the actual reading was taken could also be recorded. In order to calculate the correction that must be applied to the temperature registered by the reverser, three factors must be known:—

(*a*) The temperature of the thermometer at the moment of reading.

(*b*) The kind of glass of which it is made.

(*c*) The volume, expressed in degrees of the stem, of the secondary bulb and the portion of the stem below the 0° graduation.

Of these (*a*) is given by the auxiliary thermometer, and (*b*) and (*c*) were engraved on the back of the stem of each reversing thermometer.

All the thermometers were made of the glass known as Jenaer 16 III, and the apparent dilatation of mercury in this glass is $\frac{1}{6300}$. The correction to be applied to the reading of the reverser is given by the formula $\frac{(V^\circ + T)\ (T - t)}{6300}$, where $T =$ the temperature registered by the reverser, $t =$ the temperature shown by the auxiliary thermometer at the moment of reading, and $V^\circ =$ the volume, expressed in degrees of the stem, of the secondary bulb and the portion of the stem below the 0° mark of the reverser.

The thermometers were mounted in pairs in simple metal cases, and were attached just below the water-bottle. They were suspended in a vertical position by a catch forming part of the water-bottle; this was released by the first messenger, when the thermometers fall by their own weight and reverse; they were hauled up in this reversed position. This simple arrangement proved quite as satisfactory as any of the more complicated reversing frames which are generally in use.

CULTURE MEDIA AND METHODS.

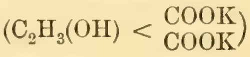
The culture media employed for isolating and counting the bacteria in plate cultures were the following:—

I. Peptone Agar.

Peptone	2·0	grammes
Potassium nitrate (KNO_3)	0·5	,,
Sea-water	1000·0	c.c.
Agar Agar	18·0	grammes (of fibre)

In the earlier work less Agar was used, but eventually it was found more convenient to use a stiffer jelly, and this did not appear to hinder appreciably the growth of the bacteria.

II. Potassium Malate Agar.

Potassium malate  $(C_2H_3(OH) < \begin{matrix}COOK\\COOK\end{matrix})$	1·0	gramme
Sodium phosphate ($Na_2HPO_4\ 12H_20$)	0·25	,,
Potassium nitrate (KNO_3)	0·5	,,
Sea-water	1000·0	c.c.
Agar Agar	12·0	grammes (of fibre)

The medium was only filtered through glass wool, so that a very slight floccular precipitate of calcium phosphate was retained.

III. Peptone Gelatin.

Peptone	2·0	grammes
Potassium nitrate (KNO_3)	0·5	„
Sea-water	1000·0	c.c.
Gelatin	150·0	grammes

This medium was only used at the Tortugas. It was necessary to keep it cooled with ice to about 20° C., as the temperature of the Laboratory sometimes rose as high as 37° C., or even higher, and Gelatin media will not remain solid at these temperatures.

The following fluid media were used:—

I. Gran's Medium (Modified).

Potassium nitrate (KNO_3)	0·5	gramme
Sodium phosphate ($Na_2HPO_4, 12H_2O$)	0·25	„
Calcium malate ($C_2H_3(OH)<\substack{COO\\COO}>Ca$), about	5·0	„
Sea-water	1000·0	c.c.

Calcium malate is only slightly soluble in water, so can be added in excess. Gran used distilled water, and added 30 grammes of Sodium chloride per litre, but in these experiments sea-water has been used instead.

II. Calcium Succinate Medium.

Calcium succinate ($C_2H_4<\substack{COO\\COO}>Ca$)	2·0	grammes
Potassium nitrate (KNO_3)	0·5	„
Sodium phosphate ($Na_2HPO_4, 12H_2O$)	0·25	„
Sea-water	1000·0	c.c.

This medium was boiled and filtered before sterilization, to remove the slight precipitate of Calcium phosphate. It was found that this medium with the addition of the phosphate gave a more vigorous growth than if it was omitted.

III. Calcium Acetate Medium.

Calcium acetate ($Ca(CH_3COO)_2$)	5·0	grammes
Sodium phosphate ($Na_2HPO_4, 12H_2O$)	0·25	„
Potassium nitrate (KNO_3)	0·5	„
Sea-water	1000·0	c.c.

Boiled and filtered before sterilization to remove precipitate of phosphate.

IV. Peptone Calcium Acetate Medium.

Calcium acetate ($Ca(CH_3COO)_2$) . . .	5·0	grammes
Peptone (Witte's)	0·2	,,
Potassium nitrate (KNO_3)	0·5	,,
Sea-water	1000·0	c.c.

The fluid media II, III, and IV were also made up with the addition of 0·2 grammes of Magnesium tartrate per 1000 c.c.

The fluid media were made up in 1500 c.c. resistance glass flasks, and 1000 c.c. of medium was used for each culture.

For other purposes a simple solution of Peptone in sea-water was employed (2 grammes to 1000 c.c.), and media were also used consisting of this Peptone solution with the addition of 0·5% of various carbohydrates, such as Cane sugar, Dextrose, Laevulose, Mannite, Lactose, etc., with sufficient Neutral Red solution to colour them, in order to test the acid-forming properties of the bacteria in the presence of Carbohydrates.

The ordinary "Koch" steam sterilizer, and an iron oven for dry-heat sterilization, were used, and gasoline cooking stoves were found to be the most satisfactory source of heat. It was found an advantage to use Petri dishes with porous earthenware covers, which enabled the water of condensation to evaporate partially; the evaporation could be checked at any time by covering the dishes with a bell-jar lined with wet filter-paper. It was usually found necessary to keep all cultures on tables with their feet standing in dishes of paraffin oil, in order to prevent the attacks of ants and other insects. In all other respects ordinary bacteriological routine was followed, and the methods need not be further particularized here.

The reduction of the Nitrate to a Nitrite in fluid culture media was tested for by the addition of 5 c.c. of 10% Sulphuric Acid and 2 c.c. of a 1% solution of Metaphenylene diamine hydrochloride to 25 c.c. of the culture. The production of a brown colouration (due to the formation of Bismarck Brown) is an indication of the presence of a Nitrite, and is an extremely delicate reaction.

The Diphenylamine and Brucine sulphate reactions were also used when testing for the presence of Nitrates.

The formation of Ammonia was tested for by the addition of 5 c.c. of 10% Potassium hydrate and 5 c.c. of Nessler's Reagent; the white precipitate formed on the addition of the Potassium hydrate does not appreciably interfere with the test, though it renders it less delicate.

Under expeditionary conditions, and in the absence of the somewhat elaborate apparatus that would be necessary in order to estimate chemically the amount of denitrification in cultures, it was only possible to compare the rate of denitrification in different cultures by noting the time taken for the first appearance of the Nitrite reaction, and the time taken for all trace of Nitrite or Nitrate to disappear. It seems that the rate of denitrification in culture media inoculated with equal volumes of samples of sea-water must be a function of the number of bacteria in the sample, the temperature at which the cultures are grown, and the specific power of denitrification of the individual species of bacteria. Considering the rapid multiplication of bacteria when the food supply is plentiful, up to a maximum determined chiefly by the accumulation of the waste products of their own metabolism, it appears that the factor of the number of bacteria in the sample may be neglected within the limits of these experiments. For example, the number of bacteria in 1000 c.c. of Gran's medium at the end of twenty-four hours would probably be much the same whether it were inoculated from a sample containing 8 or 16 bacteria per 1 c.c., similarly it was a matter of experience that the first trace of Nitrite formation was observable at about the same time, whether 5 or 10 c.c. of a given sample had been used for inoculation.

Consequently it would appear that for purposes of comparison, and within the limits of the experiments described, if the temperature be the same for the cultures compared, the rate of denitrification is a measure of the specific denitrifying power of the particular species of bacteria.

In the work on the bacterial precipitation of Calcium carbonate, the precipitate, which was often so fine as to tend to remain in suspension, was usually obtained by centrifugalization. It was either preserved in small bottles with some of the culture fluid, or else washed first with distilled water and then with absolute alcohol, and finally allowed to dry. These precipitates were sent to Dr. F. Wright of the Carnegie Geophysical Laboratory at Washington, who with great kindness reported on their mineralogical properties.

THE INVESTIGATION OF SAMPLES OF SEA-WATER TAKEN OFF PORT ROYAL, JAMAICA.

The work at Port Royal was done in May, 1911, but was of a very preliminary nature. It was necessary to depend on a sailing-boat for obtaining the samples, but owing to the remarkable regularity with which an on-shore wind springs up every morning but little difficulty was experienced from this cause. No apparatus for obtaining deep samples was available, but samples were taken from a depth of six fathoms by means of a bottle from which the stopper was pulled by a line, and then allowed to fall back into place. A measurement of the rate of denitrification in fluid culture media inoculated with samples of sea-water was made, but isolation of the bacteria on solid media was not attempted.

The following method was employed:—

Samples of sea-water were collected in sterilized stoppered bottles from the surface, and from depths of 3 and 6 fathoms, from positions about five miles from shore, where, from a consideration of the wind and tide, the water was probably under truly oceanic conditions and unaffected by the neighbouring land.

10 c.c. of these samples were added to 1000 c.c. of Gran's medium. The cultures were kept in a moderate light, and the temperature varied from 25° to 31·5° C. The average temperature during the growth of each culture was noted.

In a typical culture made from surface water, and for which the average temperature was 29° C., the first indication of the formation of a Nitrite, as given by the Metaphenylene diamine reaction appeared after 27 hours; after 38 hours the brown colour produced in this reaction was very intense, the culture became cloudy, and on testing with Nessler's Reagent slight Ammonia formation was apparent. After 48 hours the culture became very cloudy and a scum of bacterial growth developed: the Nitrite and Ammonia reactions remained unaltered. After 63 hours the Nitrite reaction was somewhat less marked, the Ammonia reaction was unaltered, and bubbles of gas began to appear. After 72 hours many bubbles of gas were being produced, and the Nitrite and Ammonia reactions were very slight. After 86 hours the bubbling had ceased, and no Nitrite or Ammonia was present in the culture. Testing the culture for Nitrates by the Brucine and Diphenylamine reactions then showed that no Nitrate was left in the solution.

In the absence of a gas analysis apparatus the nature of the gas evolved could not be determined, but considering that it was non-inflammable, did not turn lime water milky, and that the Nitrate originally present had been destroyed, it seems strongly probable that this gas was pure Nitrogen. Thus in 86 hours 0·5 gramme of Potassium nitrate had been decomposed by bacterial growth. If a further 0·5 gramme of Potassium nitrate were then added, it was rapidly decomposed, and this could be repeated many times until the other constituents of the culture medium were used up, or the accumulation of the products of metabolism had become toxic to the bacteria.

It was found that the rate of denitrification varied with the temperature, and that in cultures kept at a temperature of between 10° and 12° C. no growth or denitrification occurred. The denitrification was always more rapid in cultures from water taken from a depth of 3 or 6 fathoms than from the surface. It was also more rapid with samples taken from the thick muddy water of a mangrove swamp, where organic matter was plentiful.

The bacteria present in the cultures were very minute, actively motile bacilli with rounded ends.

An abstract of the behaviour of a few of the cultures is given below.

1. Sample collected 5 miles S. of Port Royal, wind S.E., force 4, tide rising. Sample taken from surface. 1000 c.c. of Gran's medium was inoculated with 10 c.c. of sample.

After 20 hours a slight cloud developed in the culture, and faint Nitrite reaction was given.

After 36 hours a dense cloud developed in the culture, and strong Nitrite reaction was given.

After 60 hours a dense cloud and scum developed in the culture, and strong Nitrite and faint Ammonia reaction was given.

After 70 hours a dense cloud, scum, and bubbles developed in the culture, and faint Nitrite and faint Ammonia reaction was given.

After 84 hours culture was less cloudy, with much scum, no Nitrite or Nitrate reaction, very faint Ammonia.

The average temperature at which the culture was grown was 30° C.

2. Sample collected from same spot under similar conditions, from a depth of 3 fathoms. 1000 c.c. Gran's medium was inoculated with 10 c.c. of sample.

After 20 hours a slight cloud developed in the culture and faint Nitrite reaction was given.

After 27 hours a denser cloud developed in the culture and strong Nitrite and faint Ammonia reaction was given.

After 38 hours a dense cloud and scum developed in the culture and strong Nitrite and faint Ammonia reaction was given.

After 48 hours a dense cloud and scum developed in the culture and moderate Nitrite and faint Ammonia reaction was given.

After 63 hours a moderate cloud, thick scum, and bubbles developed in the culture and faint Ammonia reaction was given.

After 72 hours a slight cloud and thick scum, no Nitrite or Nitrate, and very faint Ammonia reaction.

The average temperature at which the culture was grown was 29° C.

3. Sample collected from a spot 6 miles S. of Port Royal, wind E.S.E., force 4, high tide (slack). Taken from surface. 1000 c.c. Gran's medium was inoculated with 10 c.c. of the sample.

After 20 hours a slight cloud developed in the culture; no Nitrite reaction was given.

After 27 hours a slight cloud developed in the culture; faint Nitrite reaction was given.

After 38 hours a dense cloud developed in the culture; strong Nitrite and faint Ammonia reaction was given.

After 48 hours a dense cloud and scum developed in the culture; strong Nitrite and faint Ammonia reaction was given.

After 63 hours a dense cloud and scum developed in the culture; moderate Nitrite and faint Ammonia reaction was given.

After 72 hours a moderate cloud, scum, and bubbles developed in the culture; very slight Nitrite and faint Ammonia reaction was given.

After 86 hours a moderate cloud and scum, no Nitrite or Nitrate and very faint Ammonia reaction.

The average temperature at which the culture was grown was 29° C.

4. Sample taken from surface water of the large mangrove swamp lying N.W. of Port Henderson. 1000 c.c. of Gran's medium inoculated with 10 c.c. of sample.

After 20 hours no cloud or Nitrite reaction.

After 24 hours slight cloud and slight Nitrite reaction.

After 40 hours strong cloud and scum, strong Nitrite and slight Ammonia reaction.

After 75 hours cloud, scum, and bubbles, no Nitrite or Nitrate and slight Ammonia reaction.

The average temperature at which the culture was kept was 30° C.

5. Subculture from Culture (1). 1000 c.c. Gran's medium inoculated with 5 c.c. of culture (1) and kept at a temperature of 10° C. to 12 C. by means of ice.

After 100 hours the culture was quite clear, and gave no Nitrite reaction. It was then removed from the ice and kept at the room temperature, which averaged 30° C.

After 107 hours a dense cloud developed in the culture, and strong Nitrite and faint Ammonia reactions were given.

After 120 hours a dense cloud, scum, and bubbles developed in the culture, and moderate Nitrite and faint Ammonia reactions were given.

After 131 hours a faint cloud, scum, and bubbles developed in the culture, and very faint Nitrite and faint Ammonia reactions were given.

After 146 hours a faint cloud and scum, no Nitrite or Nitrate, and very slight Ammonia reactions were given.

Twenty cultures from samples of water taken well out to sea from Port Royal were made, and the process of denitrification followed through with each. All gave very similar and consistent results, but the rate of denitrification decreased rapidly with the temperature at which the cultures were grown: thus at an average temperature of 27° C. the first trace of the Nitrite reaction appeared after about 40 hours, and denitrification was complete after about 100 hours.

The results of precisely similar experiments that I made with samples of water taken from the English Channel near Plymouth in the autumn of 1909, showed that there the process of denitrification was very much slower, and was never complete at the room temperature (17° C.). The first trace of the formation of a Nitrite in cultures in the modified Gran's medium, as detected by the Metaphenylene diamine reaction, occurred about the fifth day, and a large proportion of the Nitrite and Nitrate always remained, even in the oldest cultures. In similar cultures incubated at 30° C. denitrification was complete by the eighth day at earliest, but uniformly consistent results were not obtained, as in some of the cultures complete denitrification never occurred, even after several months.

It would thus appear that even under similar temperature conditions, the marine bacteria in the seas off Jamaica are much more active in causing denitrification than those found in the English Channel, and since the rate of denitrification is a function of the temperature, it follows all the more that the destruction of Nitrates by bacterial agency in the seas round Jamaica must be far in excess of that occurring in the cooler waters of the English Channel.

THE INVESTIGATION OF SAMPLES OF SEA-WATER TAKEN AROUND THE DRY TORTUGAS.

The Dry Tortugas consist of a group of eight small Keys, the largest of which, Loggerhead Key, is only about $\frac{3}{4}$ mile long by $\frac{1}{8}$th wide. They are situated about 150 miles from the mainland of Florida, and form the extreme western end of the chain of the Florida Keys. The 100-fathom line lies some 30 miles to the S. and S.W. of the

Islands and then trends round in a N.W. direction; beyond the 100-fathom line the depth increases with moderate rapidity until depths of from 1000 to 1400 fathoms are reached. To the E., N.E., and N., as far as the coast of Florida, the water is shallow, the soundings showing from 20 to 30 fathoms in most places. Beyond the 100-fathom line to the southward the influence of the Gulf Stream begins to make itself felt, though the region of maximum current velocity here lies nearer the coast of Cuba. The Tortugas Keys are of purely coral formation; they consist entirely of broken shell and coral sand, and no soil is present; the greatest elevations are the hurricane ridges, which are not more than 15 feet above sea-level, and during a hurricane the islands are sometimes completely submerged. There is no vegetation on the smaller Keys, but Loggerhead Key, on which the Carnegie Laboratory is situated, is partially covered with a growth of bushes and coarse grass. There is no fresh-water supply on the islands.

From these considerations it is obvious that the risk of contamination of samples of sea-water, taken a few miles from the Keys, through land bacteria is very small, and that such samples may be taken as being truly oceanic.

The motor-yacht *Anton Dohrn*, and smaller motor-boats, made the collection of samples an easy matter, and the well-equipped Laboratory made possible fuller investigations than those attempted in Jamaica.

A number of cultures were made in Gran's medium under conditions exactly comparable to those made at Port Royal, and the rate at which the process of denitrification proceeded was observed. The results agreed almost exactly with those obtained at Port Royal, so need not be described in detail. It thus seems that the denitrifying power of the bacteria in the seas around the Tortugas is the same as that of those around Jamaica.

Cultures were also made on various solid media, and pure cultures of the various species of bacteria were isolated by plating in Petri dishes with Peptone Agar. Samples of surface water taken from various positions round Tortugas as far as possible removed from influence of the land, and collected on sunny days, gave an average count of 14 colonies per 1 c.c. of sample. Counts of several plates from the same locality, and from different localities, showed a somewhat remarkable agreement as to the number of colonies present, the highest count ever obtained being 20 and the lowest 8 per 1 c.c. Allowing for experimental error, this shows great uniformity in the distribution of bacteria in the sea round Tortugas.

The colonies appeared to be of two kinds when grown on Peptone Agar, one much more plentiful than the other. Subcultures made from these colonies in Gran's medium showed that the bacteria forming the most common type of colony produced an active denitrification, while the others grew very slowly in this medium and produced no denitrification.

The characteristics of the denitrifying form are as follows:—

The bacterium is a very minute, actively motile short rod, with rounded ends, readily giving rise to involution forms in old cultures.

On the Potassium malate, or Peptone Agar media, colonies are visible as minute white specks after 6 to 8 hours, when the room temperature averages 29·5° C. After about 18 hours the colonies are well developed; they are white in colour, circular, but with a finely irregular outline, and have a granular appearance. Superficial colonies are much elevated at first, but as growth proceeds spread rapidly over the surface of the Agar. Deep colonies remain small, circular, and discrete.

Growth is somewhat more rapid on Peptone Agar than on the Potassium malate Agar, and the older colonies develop a brownish tinge in the centre when growing on the former medium. On Gelatin Peptone (5°/₀₀ Peptone in sea-water and kept at between 20° and 25° C. to ensure the medium remaining solid) growth was very slow: in stab cultures growth proceeded slowly from the surface downwards, leaving a funnel-shaped depression of liquefied Gelatin.

Acid formation, as shown by the Neutral Red reaction, occurs in Dextrose, Laevulose, Mannite, and Cane Sugar, but not in Lactose media.

Growth is inhibited at a temperature of 10° C., but takes place slowly at 15° C.

Growth is much retarded by exposure to bright sunlight, but the bacteria are not killed by a ten hours' exposure.

The bacteria are facultative anaërobes, but growth under anaërobic conditions is very slow.

In Gran's medium growth is rapid, but no growth occurs if the Potassium nitrate be omitted, or if the Calcium malate be replaced by Calcium carbonate. Growth in a pure solution of Peptone in sea-water is slight, but becomes abundant if Potassium nitrate be added, when denitrification quickly ensues. The most rapid early growth was produced in sea-water containing 2°/₀₀ Peptone, 1°/₀₀ Potassium malate, and 0·5°/₀₀ Potassium nitrate, and in this clear medium a slight floccular precipitate, presumably of Calcium salts derived from the sea-water, was soon formed. Growth was also rapid at first in a solution of 5°/₀₀ Potassium malate and 0·5°/₀₀ Potassium nitrate in sea-water, but in this medium growth apparently ceased after a few days and denitrification was never complete; a slight precipitation occurred, and the solution was found to have very definitely increased in alkalinity.

This bacterium does not appear to have been previously described, and I propose for it the name of "Bacterium calcis," owing to its power of precipitating Calcium carbonate from solutions of Calcium salts. This point will be dealt with later in the paper.

The characteristics of the scarcer non-denitrifying form of bacterium found on the Agar plates are as follows:—

The morphological characters are exactly similar to those of *B. calcis.*

Growth on the Potassium malate Agar medium is very slow and indefinite. On Peptone Agar growth is somewhat slower than in the case of the *B. calcis.* On the surface, circular cream-coloured colonies are formed, having a brownish centre, the edges are smooth and regular, and the colony remains discrete and does not tend to spread. The deep colonies are smaller and usually ovoid in shape, and of a somewhat darker colour than those on the surface.

No growth was obtained on Gelatin media.

Acid formation, as shown by the Neutral Red reaction, occurs in Dextrose and Laevulose, but not in Cane Sugar, Lactose, or Mannite media.

Growth takes place slowly at 10° C. No visible growth occurred at 0° C., but cultures were not killed by twenty-four hours' exposure to this temperature.

Growth is retarded by light, and cultures are killed by four hours' exposure to bright sunlight.

The bacterium is a strict aërobe.

Free growth takes place in Gran's medium, but develops much slower than in the case of the denitrifying form: no growth occurs if the Potassium nitrate be omitted entirely, but takes place freely if a mere trace in excess of that normally present in the sea-water be added, though no denitrification results. Attempts were made to discover whether this bacterium had any nitrifying or denitrifying action in various culture media, but uniformly negative results were obtained. Nitrites were neither oxidized to Nitrates, nor reduced to Ammonia or free Nitrogen, and Ammonia salts were unaffected. No growth was obtained in any culture medium that did not contain at least a trace of Nitrates, so it was not practicable to ascertain whether the bacterium had a nitrifying action without the necessary facilities for quantitative work.

On one occasion samples were obtained from various depths up to

90 fathoms at a point near the Gulf Stream region, 25 miles south of Tortugas. Exhausted glass flasks, with capillary necks which could be broken off at the required depth, were used for the purpose.

These samples were plated in the Peptone Agar medium and counted with the following average results :—

Depth in fathoms.	Denitrifying forms. (Bacterium calcis.)	Non-denitrifying forms.	Number of Colonies developing from 1 c.c. of sample.
0	9	2	11
10	25	4	29
40	2	2	4
60	5	3	8
90	5	6	11

It is probable that these figures are not very reliable, especially for the greater depths, since it is possible that many of the bacteria were killed by the sudden reduction of pressure to which they were exposed as the water entered the exhausted bulb.

THE INVESTIGATION OF SAMPLES TAKEN FROM A POINT 70 MILES WEST OF USHANT ISLAND, FRANCE.

This spot was chosen as it is sufficiently far out in the Atlantic to be largely out of the influence of the English Channel water. The object was to investigate truly oceanic bacteria, and previous work in 1909 had shown that the bacterial flora of the Channel water was relatively very complicated, probably owing to the presence of littoral forms. The Marine Biological Association of the United Kingdom very kindly sent their s.s. *Oithona* from Plymouth for this work, and gave me every facility both on board and in their Laboratory. As in Tortugas, the deep samples were collected in exhausted glass flasks, and accordingly, as previously explained, the results obtained from the deep samples cannot be considered to possess any very great degree of accuracy.

Attempts were made to plate the samples in Peptone Agar on board the boat, but the result was not satisfactory, as owing to the motion of the boat the jelly set in irregular waves and lumps. Consequently the samples were kept on ice, and cultures were made from them at Plymouth 24 hours after collection. It is clear that if in the future attempts are made to make plate cultures on board a small boat in rough weather, a very delicately swung table will be necessary, or else the roll-tube culture method must be employed.

Three plates on Peptone Agar were made from each sample, 1 c.c. of the sample being used for each plate. The plates were kept at the room temperature, averaging about 20° C., and the colonies were well developed after 48 hours: they appeared to be all of one kind. A count gave the following results:—

Depth in fathoms.	Number of colonies developing from 1 c.c. of sample.
0	7
10	9
20	6
30	5
50	6
70	30
80	20

The increase in the number of colonies at 70 and 80 fathoms is somewhat remarkable, but no conclusions in this respect can be drawn from one series of observations.

The characteristics of this bacterium are as follows:—

Morphologically it resembles the *B. calcis* already described.

On Peptone Agar after about 36 hours at 20° C., the colonies are white in colour, circular, with a finely serrated outline and a coarsely granular appearance. Superficial colonies grow very rapidly, and may spread as a whitish semi-transparent growth of irregular shape over the surface of the Agar. The deep colonies remain small, globular, and discrete. In old Agar cultures a brownish tinge is developed, and the colour may diffuse through the substance of the Agar. On Gelatin Peptone growth was rapid: in stab cultures growth proceeded from the surface downwards, leaving a funnel-shaped depression of liquefied Gelatin, and eventually all the Gelatin became liquefied.

Acid formation, as shown by the Neutral Red reaction, took place in Dextrose, Mannite, and Laevulose, but not in Cane Sugar or Lactose media.

1000 c.c. of Gran's medium, inoculated on board with 10 c.c. of a surface sample immediately after collection, and kept at an average temperature of about 20° C., showed the first trace of Nitrite formation after 70 hours. After 84 hours a very strong Nitrate reaction was obtained, and a slight Ammonia reaction was given with Nessler's reagent. The process of denitrification, even after the lapse of weeks, did not extend beyond this, and no bubbles of gas were formed. Other experiments made with subcultures from Agar and Gelatin media gave similar results, so that it appears that this bacterium cannot entirely break down Nitrates at a temperature of 20° C. The optimum temperature for denitrification produced by this bacterium appears to be about 20° C., as the process was less rapid at average temperatures of 17° C. and 25° C. At a temperature of 32° C. rapid growth took place, but no denitrification resulted.

It should be noted that these temperature observations were only made with subcultures from colonies on Peptone Agar and Peptone Gelatin media, and it is possible that the power of denitrification becomes diminished after cultivation on such media. Further and more accurate temperature experiments are required in which the culture medium is directly inoculated with freshly collected samples of water.

This bacterium appears to be closely related to the *Bacterium calcis*, its chief points of difference being—

1. Lesser denitrifying power and lower temperature optimum for denitrification.
2. More rapid growth on Gelatin media.
3. Absence of acid formation in media containing Cane Sugar.

INVESTIGATION OF SAMPLES OF WATER FROM THE MARQUESAS KEYS AND THE EXPERIMENTAL PRECIPITATION OF CALCIUM CARBONATE BY BACTERIAL AGENCY.

The Marquesas Keys constitute a coral atoll which forms part of the long chain of Keys separating the Gulf of Mexico from the Straits of Florida. Within the atoll the water is very shallow, and the bottom consists of a fine chalky mud many feet deep. Samples of the water from within the atoll were sent to me at Plymouth by post, and examined fourteen days after collection.

On plating on Peptone Agar, an average of 800 colonies per 1 c.c. of the sample were obtained. These colonies appeared to be all of one species, and in appearance and all cultural characteristics were identical with the *Bacterium calcis* previously described as occurring around the Tortugas.

A suspension of these bacteria from a culture on Peptone Agar was made in sterile sea-water, and a similar suspension containing roughly the same number of bacteria was made from a third subculture on Peptone Agar of the bacteria obtained from the station 70 miles west of Ushant. 1 c.c. of each of these suspensions was then added to 1000 c.c. of the modified Gran's medium: some of these cultures were kept at an average temperature of 20° C. and others at 32° C., with the following results:—

At 20° C. cultures from Marquesas showed trace of Nitrite after 45 hours.
.. .. gave strong Nitrite reaction after 53 hours.
.. .. .. 70 miles W. of Ushant showed trace of Nitrite after 140 hours.
.. .. .. 70 miles W. of Ushant showed strong Nitrite reaction after 162 hours.

In both cases a slight amount of Ammonia was recognizable by Nessler's reagent when the Nitrite reaction was strong, but decomposition of the Nitrite did not proceed further, even after 14 days.

At 32° C. cultures from the Marquesas showed trace of Nitrite after 18 hours.
.. .. gave strong Nitrite reaction after 22 hours.
.. .. .. 70 miles W. of Ushant never gave Nitrite or Ammonia reaction.

The culture from the Marquesas showed a slight amount of Ammonia formation, but the decomposition of the Nitrite did not proceed further.

From these experiments it appears that the bacteria from subcultures from the Marquesas have a much greater denitrifying power than those from subcultures from a point 70 miles west of Ushant, and that as the bacteria from the Marquesas appear to be of the same species as those investigated at the Dry Tortugas, their power of causing complete denitrification in Gran's medium has been lost by successive cultivations on Peptone Agar.

The presence of the thick layers of fine chalky mud within the Marquesas Keys, and elsewhere in many places near the Florida coast, led to a consideration of the possibility of its precipitation by bacterial agency.

Since these bacteria grow freely in Gran's medium, the Calcium salt of a simple organic acid is a sufficient source of organic food for them, and it seems probable that they would thrive in sea-water containing the products of decomposing vegetable matter, provided that the Nitrate supply, and conditions of light and temperature, were suitable. Such conditions should be especially well fulfilled by the drainage into the sea of a well-wooded country with a calcareous subsoil, and the soluble organic calcium salts would be precipitated as Calcium carbonate by the action of the bacteria. In addition, the elimination of the acid radical from the Nitrate in the process of denitrification, by whatever stages it may occur, must leave the alkaline base free to destroy the normal equilibrium of the salts in sea-water, and by increasing the alkalinity, would also result in the precipitation of Calcium carbonate.

To test this theory cultures were made in a medium having the following composition:—

Calcium succinate . . .	2·5 grammes
Potassium nitrate . . .	0·5 ,,
Sea-water	1000·0 c.c.

Calcium succinate is soluble in these proportions, and the medium is quite clear. Free growth was manifested by the cloudiness of the medium 48 hours after inoculation, and Nitrite formation was apparent.

After 96 hours the medium appeared quite milky, and this milkiness was due to the presence of exceedingly fine particles of a substance which was soluble in dilute Hydrochloric Acid with evolution of gas, and was presumably Calcium carbonate. In some cultures these particles settled as a definite sediment, but in others the particles were so minute that they showed little tendency to settle, and could only be separated by centrifugalization. The conditions determining the size of the particles formed could not be ascertained, as the size varied in cultures which were apparently made and grown under identical conditions.

The addition to cultures in which the particles of Calcium carbonate were so small as to remain in suspension of any foreign substance, such as finely powdered Calcium sulphate, or of larger particles of sand, resulted in the aggregation around them of the particles of Calcium carbonate, forming a concretion around a central nucleus. These concretions were hard and of almost crystalline appearance under the microscope, and were soluble in dilute Hydrochloric Acid with evolution of bubbles of a gas which, when the operation was performed on a microscopic slide, could be completely absorbed by running in a solution of Sodium hydrate under the cover-slip. Once this process of concretion had been initiated, it appears to progress independently of the presence of particles which act as nuclei, and a large concretion may often be found having a number of smaller concretions around it, or continued into a chain of small spheres, the whole presenting somewhat the arrangement shown by freely budding yeast cells. The deposition of this form of Calcium carbonate also takes place on the sides of the flask, and more especially over any area where the glass is scratched or roughened.

From these results it would seem strongly probable that the layers of fine unorganized chalky mud found in the Marquesas Keys are being precipitated by the action of the *Bacterium calcis*, and it would seem a reasonable suggestion that similar bacterial action may have played an important part in the formation of chalk and other limestone formations in geologic times. The formation of semi-crystalline concretions round a central nucleus at first seemed to suggest an explanation of the formation of oölite grains, but a mineralogical examination, very kindly made by Dr. Fred. E. Wright, showed that the concretions did not possess that laminated structure characteristic of oölite grains, and that their crystalline structure was nearer that of Calcite than Aragonite.

SOME CONSIDERATIONS ON THE PHYSIOGRAPHY OF THE TONGUE OF THE OCEAN AND ANDROS ISLAND, BAHAMAS, B.W.I.

The position of the Tongue of the Ocean is shown in the map on page 507, which includes the greater part of the Bahama group, and shows its position relative to Florida and Cuba. The Tongue consists of a long and narrow stretch of deep water, running in a N.N.W.–S.S.E. direction, and except at its northern end it is completely surrounded by shallows or by land. On the west, for about three-quarters of its length, it is bounded by the coast of Andros Island; south of Andros it is separated from the Santaren Channel by some 60 miles of shallow water lying over the Great Bahama Bank. To the south it is separated from the Old Bahama Channel by over 50 miles of shallows, averaging not more than 3 fathoms in depth. To the east it is separated from the deep water of Exuma Sound by from 20 to 40 miles of shallow water of from 2 to 3 fathoms in depth, and by the chain of islands and cays extending in a N.N.W. direction from Great Exuma Island. The mouth of the Tongue of the Ocean lies between New Providence Island on the east and the northern extremity of Andros Island on the west; it is here some 25 miles wide, and it maintains this width for the greater part of its length as it stretches south. Between the southern extremity of Andros and Green Cay it narrows to under 20 miles, but south of this point it expands eastwards into an almost circular terminal basin of about 35 miles diameter. The total length is about 120 miles.

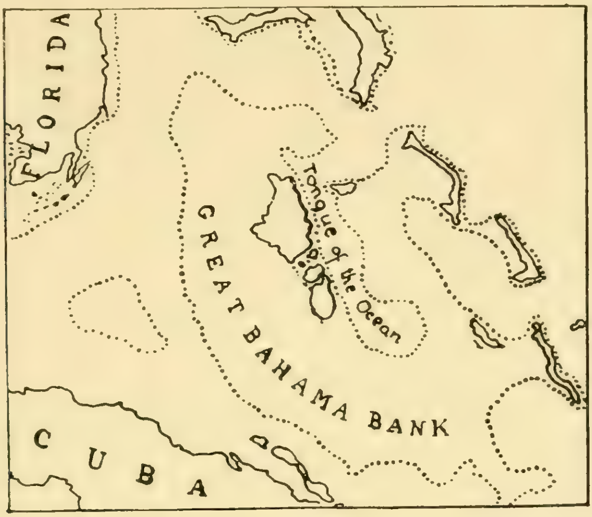


Fig. 1.—Map showing position of the Tongue of the Ocean. The dotted line shows the 100-fathom line; in most parts this almost coincides with the 5-fathom line.

To the north, the Tongue is connected by a stretch of deep water extending in a N.E. direction, with the Providence N.E. Channel, and the Providence N.W. Channel, leading respectively into the Atlantic and the Straits of Florida, and thus the Tongue of the Ocean is brought into direct connection with the two main divisions of the Gulf Stream.

The soundings in this area show a slight but regular upward gradient from a depth of 1084 fathoms at the mouth, to 740 fathoms in the southern terminal basin. Along the margins the gradient is extremely steep, and along the coast of Andros our observations showed that it was almost perpendicular at a distance of from a quarter to half a mile from the shore, but unfortunately no complete observations have been made from which this gradient could be calculated. When attempting to make soundings in this area, the sinker (a 30-lb. conical iron weight) in every case was caught upon what was probably some projection on a submarine cliff, and it was impossible to free it; after several such attempts and loss of sinkers the soundings were abandoned. The entrance to the Tongue by the Providence N.E.

Channel is of steadily increasing depth, up to 2200 fathoms at its junction with the still deeper water of the Atlantic; the Providence N.W. Channel becomes shallower at its junction with the Straits of Florida, and between Great Isaac and the western end of Bahama Island is only between 200 and 300 fathoms in depth.

The surface water of the Tongue of the Ocean, except along the coast of Andros, is everywhere continuous with that overlying the thousands of square miles of shallows forming the Great Bahama Bank, and the flats and cays lying to the north and west of the Exuma Islands, whereas the deeper water is only connected with the outer ocean by the comparatively narrow entrance between New Providence and the north of Andros, leading, after a turn of about 90°, into the Providence N.E. and N.W. Channels.

The Laboratory from which this work was done was established at Golding Cay, at the eastern mouth of the South Bight of Andros; this position was especially suitable for the work, as by running out a few miles in a direction at right angles to the coast-line the middle of the Tongue of the Ocean could soon be reached, and also the mud-flats to the west of the island were readily accessible by water, as the South Bight runs right through the island to the west coast. In this region the tides are not strong, the average rise and fall being from 2 to 3 feet. Much difficulty was experienced in getting any definite information as to the set of currents in the Tongue; our local pilot stated that a current would set in a southerly direction for weeks at a time, and then without any apparent reason or change of wind would reverse and set in a northerly direction for several weeks, but such information derived from the negro natives cannot be relied on. When taking observations on May 8th, May 11th, and May 23rd, we experienced a distinct southerly drift on each occasion, but the amount of this drift was not determined, and in addition the drift caused by the wind was an unknown factor. On May 8th the wind was S.S.E., of about force 1 at 8.30 a.m., freshening to about force 3 at 10.30 a.m.; a rough estimate from the landfall on returning gave the drift of the boat as about 2 miles south during the four hours occupied in working the station; the boat had a large awning and exposed a considerable area to the wind, and had drifted this distance against the wind, so it would seem that on that occasion there must have been a strong current setting south.

Andros Island consists of a limestone formation, the exact nature of which has been dealt with by Wayland Vaughan (17). The greater part of the island is very flat, and is only elevated a few feet above sea-level: a few irregular undulations, never more than 100 feet high, are found especially along the east coast. There is evidence to show that formerly the level of the land was much higher than at present, and signs of rapid erosion of the rock are everywhere obvious. One of the most remarkable features is the absence of soil even in the well-wooded parts of the island, the trees and bushes growing directly out of crevices and holes in the rock, and giving rise to practically no leaf mould. In the numerous "pot holes" which occur all over the island, a small deposit of black leaf mould can be found, and these "pot holes" are the favourite places for the cultivation of sugar-canes and bananas. The erosive action of water on the rock is especially noticeable where the slow drainage from an inland swamp can be traced in its course to the sea: in such a locality the hard rock is eroded, honeycombed, and undermined to a most remarkable degree, even though the amount of drainage, except after the heaviest rains, can scarcely be more than a slow trickle. Erosion of the rock along the sea-coast, where it is exposed to the action of the sea-spray, is also very marked. From the occurrence of this erosion it is obvious that all the water draining from the land into the sea must contain a high proportion of Calcium salts in solution.

Towards the west of the island the land is remarkably flat, and near the coast consists of white chalky mud, which has partially dried, and in places has formed a harder crust on the surface. These half-dried mud-flats slope almost imperceptibly into the sea, and are continuous with the submarine flats which extend some sixty miles off the west coast with an average depth of from two to three fathoms. The mud forming these submerged flats is very soft, and near the coast it was easily possible to push a twelve-foot sponge pole down to its full length into it without touching any harder material: the surface layer of the mud for a depth of about six inches is of a creamy white colour, but below that it is of a greyish tinge and has a slight odour of sulphuretted hydrogen. Unfortunately there was no opportunity of obtaining information as to the real thickness of this layer of mud, nor of investigating more than the surface layers at any distance from the coast.

Microscopical examination showed that this mud was almost entirely composed of minute unorganized particles of Calcium carbonate. Near the shore a good deal of organic matter, chiefly in the form of decaying mangrove roots, was present. Further out little organic matter was noticeable, but it was not possible to examine the deeper layers of the mud in these situations: the only organic matter that was seen consisted of the rootlets of a species of Zostera, which was found in occasional patches some miles off the coast.

BACTERIAL INVESTIGATIONS IN THE DEEP WATER IN THE TONGUE OF THE OCEAN.

Continued bad weather during the whole of our stay at Andros greatly added to the difficulties of these investigations, and on this account it was only found possible to work three stations. The last two were worked under the most disadvantageous conditions, the quick roll of the boat making the filling of the water-bottle with Alcohol, and the syphoning off of the sample under sterile conditions, a matter of the greatest difficulty.

The first station worked was situated six miles due east of Golding Cay, the second 14 miles E. of Golding Cay, and the third 10 miles E.N.E. ¼ E. of Golding Cay. The three stations were thus situated at the angles of a triangle which was nearly equilateral, the base being a little longer than the sides, and running due east and west.

At the first station, worked on May 8th, bottom was sounded at 822 fathoms. The sea was calm at first, with a S.S.E. swell, but became choppy later. The wind was S.S.E., force 0 to 1 at 8.30 a.m., freshening to about force 3 at 10.30 a.m. The sample of the bottom obtained by the snapper rod was of a very stiff clay-like consistency, greyish white in colour, and was composed of very minute unorganized particles of Calcium carbonate, containing a few pteropod and globigerina shells. The following temperatures, to which the necessary corrections have been applied, were recorded:—

Depth in fathoms.	Temperature in degrees Centigrade.	
Surface	26·90	
10	25·90	
50	25·14	
100	22·00	
200	17·13	
400	9·03 8·93	average = 8·98
600	4.78 4·62	average = 4·70
Bottom (822 fths.)	4·00 3·94	average = 3·97

These samples, without previous dilution, were plated in Peptone Agar, 1 c.c. of the sample being used for each plate. The Agar was cooled to just under 40° C. before plating. It is very necessary that this temperature should not be exceeded, as many marine bacteria are very sensitive to heat: the use of Agar at as high a temperature as 45° C. will cause the death of a large proportion of the bacteria, though in the process of plating they can only be exposed to this temperature for a very short time. The cultures were kept in the dark at the room temperature (averaging about 28° C.), and at the end of 24 hours a free growth of colonies was apparent. At the end of 48 hours the plates were counted with the following results:—

Depth.	Number of colonies developing from 1 c.c. of sample.
Bottom (822 fathoms)	0
" "	3
" "	1
600 fathoms	17
" "	14
400 fathoms	15
" "	16
200 fathoms	1760 Very much overcrowded, indications of presence of many more colonies which have not developed owing to overcrowding.
" "	1500
100 fathoms	uncountable owing to overcrowding.
" "	" " " "
50 fathoms	uncountable " " "
" "	" " " "
10 fathoms	uncountable " " "
" "	" " " "
Surface	uncountable " " "
"	" " " "

From these counts it is apparent that the number of bacteria falls off at some point between 200 and 400 fathoms.

The second station was worked on May 11th, at a point 14 miles due east of Golding Cay. The sea was calm at first, and the wind E.N.E., force 1, but later in the day a heavy swell set in and the wind freshened to about force 4; eventually the weather became so bad that it was impossible to work, and the station had to be abandoned before it was completed. Bottom was sounded at 890 fathoms, but there was some stray on the wire, so that the true depth was probably about 825 fathoms, as shown by the chart. The bottom consisted of fine white calcareous ooze; no remains of pteropods were seen, but some globigerina shells were present. The following temperatures were recorded:—

Depth in fathoms.		Temperature in degrees Centigrade.
Surface...		26·30
10		26·40
50		24·89
100		22·63
200		17·42
300	14·37 14·27	average = 14·32
400	9·86 9·73	average = 9·79
Bottom...	4·17 4·13	average = 4·15

Samples down to a depth of 200 fathoms were diluted 1 in 100 with sterilized sea-water before plating. The following results were obtained after 48 hours' growth:—

Depth in fathoms.	Number of colonies developing from 1 c.c. of sample.
Surface	16,200
10	13,100
50	14,000
100	14,000
200	15,000
300	14
400	12

The figures given represent the mean of the number of colonies developing in the two plates that were made from each sample. It is here apparent that the number of bacteria per 1 c.c. falls off very rapidly between 200 and 300 fathoms.

The third station was worked on May 23rd at a point 10 miles

E.N.E. ¼ E. of Golding Cay. The wind was east, of about force 4: as it had been blowing for the previous ten days without intermission, the sea was so rough that it was only possible to work when steaming slowly ahead into the wind. This resulted in the production of a great deal of stray on the sounding wire, so that the number of fathoms of wire run out is greater than the actual depth at which the samples were taken; these differences will be large for the more superficial samples, but small at greater depths, as the wire strays in a curve whose gradient becomes very steep a little below the surface, under these conditions.

The following temperatures were recorded:—

Length of wire run out in fathoms.	Temperature in degrees Centigrade.
Surface	27·10
20	26·50
100	22·80
160	18·83
250	14·97 15·00 } average = 14·98
350	10·85 10·84 } average = 10·85

At this point the station had to be abandoned owing to the bad weather. The samples down to 160 fathoms were diluted 1 in 100 with sterilized sea-water before plating in Peptone Agar; the remaining two were plated undiluted. At the end of 48 hours the following counts were made:—

Length of wire run out in fathoms.	Number of colonies developing from 1 c.c. of sample.
Surface	15,000
20	15,500
100	13,700
160	13,300
250	14,300
350	16

These numbers represent the mean of the number of colonies in the two plates made from each sample.

The colonies developing in all the cultures were only of two kinds, the *Bacterium calcis*, and the non-denitrifying species already described. The non-denitrifying species formed a relatively small proportion of the total, and they were not found at all in cultures made from samples taken below 250 fathoms. As they appear to be comparatively chemically inactive, and as nothing is at present known concerning the part played by them in the metabolism of the sea, they will not be further considered here.

A consideration of these results obtained in the Tongue of the Ocean shows that the waters down to a depth of somewhere about 300 fathoms in April, 1912, contained an enormously larger number of bacteria than the water in the neighbourhood of Tortugas in June, 1911. The number of bacteria falls off from about 14,000 to about 12 per 1 c.c. between depths of 250 and 350 fathoms; the temperature at 250 fathoms was about 15° C., and at 350 fathoms about 11° C., and it was shown in June, 1911, at Tortugas that *B. calcis* will grow slowly at 15° C., but that growth is totally inhibited at 10° C. It would thus seem that the observed distribution of the bacteria agrees fairly with what might be expected from the temperature conditions.

As regards these observations as to the occurrence of bacteria in small numbers at depths below 350 fathoms, the possibility of experimental error must be considered: a leakage into the water-bottle of 0·25 c.c. as it was being hauled up through the last 300 fathoms would account for the number found, and there are also many possible sources of error in the process of siphoning off the sample, and making the cultures, where a permanent Laboratory is not available. It is possible that the water below 350 fathoms was really sterile, though if so the constancy of the results obtained is curious, if it is to be ascribed to experimental error. In any case, the small number of bacteria found at depths below 350 fathoms can play no part in the metabolism of the sea, since it has been shown that at the temperatures obtaining at these depths *B. calcis* is incapable of growth.

The much greater abundance of bacteria in the surface waters of the Tongue of the Ocean than in the waters round Tortugas may perhaps be accounted for by the fact that in the former locality by far the greater part of the surface water must flow over the immense chalky mud flats and shallows which bound it in most directions, and, as will presently be shown, these mud flats are phenomenally rich in bacteria, and are probably still being deposited by bacterial agency.

HYDROGRAPHIC OBSERVATIONS IN THE TONGUE OF THE OCEAN.

The samples of water taken for hydrographic observations were analysed by Mr. D. J. Matthews at Plymouth. With great kindness he calculated the results, and from his notes the following observations and conclusions are drawn.

The samples were analysed for salinity in comparison with the standard sea-water supplied by the Central Laboratory of the Conseil International pour l'Exploration de la Mer, and hence the results are strictly comparable with all other analyses published under the auspices of this International Council.

At the first station, 6 miles east of Golding Cay, the following results were obtained :—

Depth in fathoms.	Temperature.	Cl‰.	S‰.	σ_0.	σ_t
0	26·90	20·06	36·24	29·12	23·70
10	25·90	20·46	36·96	29·71	24·57
50	25·14	20·43	36·91	29·66	24·76
100	22·00	20·28	36·64	29·45	25·48
200	17·13	20·08	36·27	29·15	26·48
400	8·98	19·58	35·37	28·43	27·43
600	4·70	19·49	35·21	28·30	27·90
822	3·97	19·367	34·98	28·11	27·79

Note.—The original surface sample was lost owing to breakage of the bottle in transit to England. The analysis was made on a sample taken three days later at the same spot.

In this table Cl ‰ means the weight of Chlorine in grammes found in 1000 grammes of sea-water. S‰ means the salinity, or the total weight of salt in grammes found in 1000 grammes of sea-water. σ_0 represents the specific gravity of the sample at 0° C., and σ_t represents the specific gravity of the sample at the temperature "t" at which it was collected, with no correction for pressure.

At the second station, 13½ miles east of Golding Cay, the following results were obtained :—

Depth in fathoms.	Temperature.	Cl‰.	S‰.	σ_0.	σ_t
0	26·30	20·25	36·58	29·40	24·15
10	26·40	20·33	36·73	29·52	24·23
50	24·89	20·395	36·84	29·61	24·78
100	22·63	20·36	36·78	29·56	25·42
200	17.42	20·12	36·35	29·21	26·47
300	14·32	19·81	35·79	28·76	26·75
400	9·79	19·56	35·34	28·40	27·27
890	4·15	(No sample; bottle did not work.)			

Owing to the uncertainty of the depths at the third station, due to the bad weather and consequent stray on the wire, it was decided not to include these observations in a consideration of the hydrographic conditions, and to make what deductions were possible from the results obtained at the two stations given.

It is interesting to note that at the *Challenger* Station, No. 27, in 22° 49′ N., 65° 19′ W., March 28th, 1873, where the depth was 2960 fathoms, the actual temperature reading at 200 fathoms was 17·22° C., and that this agrees more closely with the temperatures in the Tongue of the Ocean than that taken from the *Challenger* smoothed curve, which was 18·17° C.

From this diagram it can be seen that the surface salinity increases from west to east very rapidly, 0·34‰ in 7½ miles, but the surface temperature is fairly uniform, between 26° C. and 27° C.

At both stations the salinity increases downwards to a maximum probably lying between 10 fathoms and 50 fathoms, but more rapidly at Station I, so that from 10 fathoms to 50 fathoms the salinity decreases from west to east.

Below 100 fathoms the conditions are closely similar at both stations, as far as the observations go; the salinity decreases fairly rapidly to 400 fathoms and then more slowly to the bottom.

The temperatures decrease rapidly and uniformly from the surface to about 500 fathoms, then more slowly to the bottom.

There is practically no thermocline (German *sprungschicht*) at any depth, and the salinity shows only a poorly marked discontinuity layer, confined to the upper stratum. This absence of a thermocline is remarkable.

In general, below about 250 fathoms the temperatures and salinities agree with the nearest stations of the *Michael Sars* in the open Atlantic;

above this depth they are higher, and differ from them and the open ocean, north of the belt of calms, in the absence of a temperature thermocline and in the maximum salinity being found below the surface. The latter points either to a considerable local supply of fresh water, or to a current of lower salinity from either the Florida stream or the region of equatorial calms. Unfortunately we have no reliable salinity observations for the two latter.

The following section shows the vertical distribution of layers of different salinities and temperatures at the two stations in diagrammatic form :—

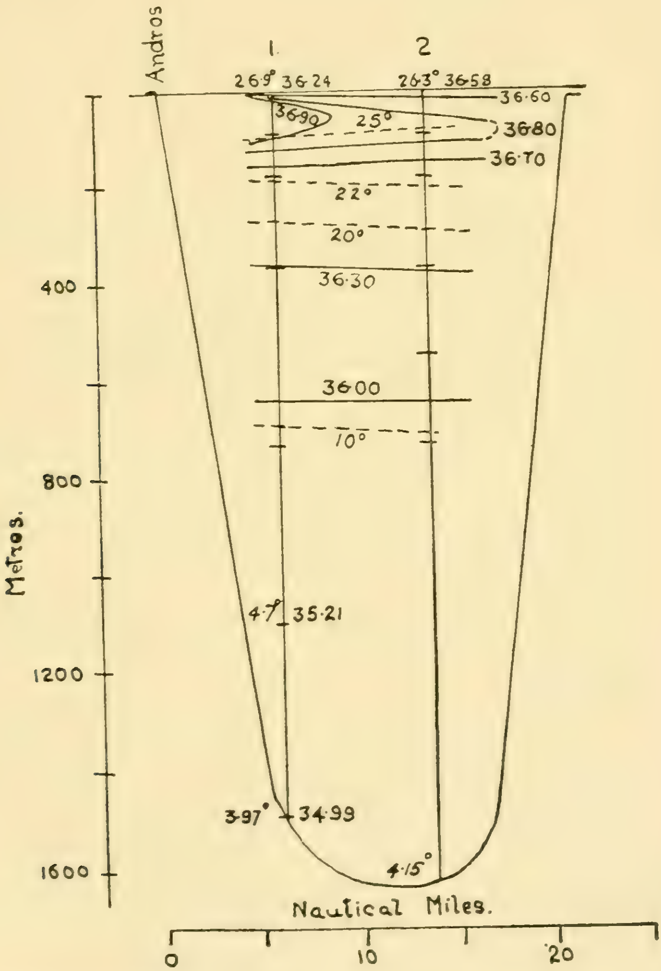

Andros
1.
2
26·9° 36·24
26·3° 36·58
36·60
36·90
25°
36·80
36·70
22°
20°
36·30
36·00
10°
4·7° 35·21
3·97° 34·99
4·15°
400
800
1200
1600
Metres.
Nautical Miles.
0
10
20

FIG. 2.—Section across the Tongue of the Ocean from Golding Cay, Andros Island eastwards. Broken lines = isotherms, continuous lines = isohalines.

With regard to the accuracy of the work, Mr. Matthews makes the following remarks :—

" *The accuracy of the observations.*

(a) *Salinity.*—The method of taking the samples from the water-bottle was rather inconvenient, as a siphon was used; the samples were also very small, but well preserved. The water-bottle itself might have leaked or closed at the wrong depth, as was the case with earlier models. That this was not so is shown by:

1. The sharp fall in the number of bacteria at between 200 and 300 fathoms.
2. The close agreement of the salinities at 400 fathoms, the greatest depth at which they were taken on both stations: Station I gave 35·37, Station II 35·34.
3. The close agreement between the bottom salinity at Station I, 34·98 at 822 fathoms, and the salinity found at the same depth at the nearest position at which we have modern observations, i.e. Michael Sars, Station 65, in 37° 12′ N., 48° 30′ W., June, 1910: according to the curve this is about 34·96.

The water-bottle only failed once, at about 890 fathoms at Station II.

(b) *Temperatures.*—The National Physical Laboratory correction was given to 0·1° only, but the readings below 15° are comparable among themselves to 0·05° or possibly less. The curves of temperature for the two stations agree well in shape below 300 fathoms, but the temperature on Station II is generally slightly higher than on Station I: as a rule by an amount corresponding to a difference of depth of about 20 to 25 fathoms.

Below 200 fathoms the curves for both stations agree very closely with that for Michael Sars Station 64, in 34° 44′ N., 47° 52′ W.

It is almost certain from the above considerations that the results are only incorrect by the experimental errors in measuring the depth, in determining the salinity (0·02 at most), and perhaps 0·1° C. of temperature."

These observations are sufficient to show that the Tongue of the Ocean is an area of considerable interest from a hydrographical point of view, and it is much to be regretted that the continued bad weather during our stay made it impossible to obtain more observations and samples.

BACTERIAL INVESTIGATION OF THE CHALKY MUD-FLATS WHICH ARE BEING DEPOSITED TO THE WEST OF ANDROS ISLAND.

Samples of the mud were taken from the western entrance of South Bight, and from points two and three miles out from the shore: practically identical results were obtained from all these localities. The sample at the mouth of the Bight was taken in about 4 feet of water, that two miles out in 7 feet, and that three miles out in 8 feet. The samples were necessarily taken from the surface of the mud.

For bacterial examination, one part of this mud was shaken up with three parts of sterilized sea-water; this was allowed to settle for 15 minutes, and then the clearer surface layer was diluted 1 in 1,000,000 with sterilized sea-water. The diluted fluid was plated in Peptone Agar, 1 c.c. being used for each plate. The count of a number of plates after 48 hours gave 40 colonies as an average, and thus the surface mud itself must contain about $40 \times 4 \times 1{,}000{,}000 = 160{,}000{,}000$ bacteria per 1 c.c. The actual number in the mud may exceed this figure, since a large proportion of the bacteria would possibly settle with the larger particles after the first dilution.

The bacteria found in these cultures were nearly all the *B. calcis*, only occasionally were a few colonies of the non-denitrifying species seen.

A sample of the water taken from the surface at a spot three miles out from the western entrance of South Bight gave a count of 35,000 colonies per 1 c.c., the great majority of these being *B. calcis*.

Subcultures of *B. calcis* were made in Gran's medium, and in the Calcium succinate, Calcium acetate, and Peptone Calcium acetate media, whose composition has already been given. Denitrification in all these media was rapid and eventually complete, and was accompanied by the precipitation of Calcium carbonate. In the last three media, which contained no solid matter and were quite clear and transparent before inoculation, this precipitation was manifested after twelve hours by the formation of a thick white cloud in the fluid, readily distinguishable from the cloudiness produced merely by bacterial growth. The development of this precipitate continued rapidly during the first forty-eight hours, but in many cases it was composed of such fine particles that they showed little tendency to settle to the bottom of the flask; in other cases larger particles were formed, and a sediment similar in appearance to the chalky mud of the mud-flats was produced. The exact conditions determining the size of the particles precipitated could not be ascertained, as the size varied largely in cultures made at the same time, in the same media, and kept apparently under the same conditions. The addition of Magnesium tartrate in small quantities (0·2 grammes per 1000 c.c.) to the culture media seemed to induce the precipitation of larger particles, but it did not appreciably affect the rate of growth of the bacteria.

In some of the older cultures that had been kept for a week or more, the sides of the flasks were coated with a thin layer consisting of extremely minute rhombohedral crystals of Calcium carbonate. Occasionally these crystals formed around small bubbles that had remained near the surface of the fluid, the weight of the crystals eventually caused the bubbles to sink, and then the contained gas became dissolved; in this way a number of small hollow spheres were formed, their walls consisting of minute crystals of Calcium carbonate. The formation of these curious bodies occurred especially readily in the Calcium succinate medium to which 0·2 grammes of Magnesium tartrate per litre had been added. The deposition of Calcium carbonate in a distinctly crystalline form was only noted in old cultures, and then it was in an amount relatively extremely small when compared to the precipitate of apparently amorphous Calcium carbonate.

Specimens of the precipitates from some of the culture media were sent to Dr. Fred. E. Wright, of the Geophysical Laboratory of the Carnegie Institution, who with great kindness examined them, and described them as follows:—

"Preparation I. Precipitate from medium composed of—

Calcium acetate	5·0	grammes
Potassium nitrate	0·5	,,
Peptone (Witte's)	0·2	,,
Sea-water	1000·0	c.c.

Filtered and sterilized.

"Contains two substances: (1) Fine grains of a strongly birefracting, apparently uniaxial, optically negative substance, and with refractive index about 1·66. This is probably calcite. The grains are isolated, and no evidence of spherulitic crystallization was observed. On treatment with very dilute Hydrochloric Acid, a noticeable evolution of Carbon dioxide took place. (2) Scattered through the preparation are fine needles of a weakly birefracting substance of about 1·525 refractive index; extinction angle large. These needles are evidently selenite (hydrated Calcium sulphate).

"Preparation II. Precipitate from medium composed of—

Calcium succinate	2·0 grammes
Magnesium tartrate	0·2 ,,
Potassium nitrate	0·5 ,,
Sea-water	1000·0 c.c.

"This preparation consists largely of a cryptocrystalline aggregate of a weakly birefracting substance, whose refractive index is about 1·52 to 1·53. This substance proved too fine for further determination. Scattered through this substance are rounded and irregular patches of a second cryptocrystalline substance of strong birefringence, which gives off CO_2 when treated with dilute hydrochloric acid, and is probably calcite.

"Preparation III. Precipitate from a medium composed of—

Calcium acetate	5·0 grammes
Sodium phosphate (Na_2HPO_4, $12H_2O$) .	0·25 ,,
Potassium nitrate	0·5 ,,
Sea-water	1000·0 c.c.

"This preparation is again very fine grained, and consists (1) in large measure of minute grains of a substance which agrees with calcite in its optical properties in so far as they could be determined. On immersion in dilute HCl a distinct evolution of CO_2 gas was observed. (2) Of a substance whose grains are somewhat coarser than the calcite grains, their birefringence being medium to weak; refractive index about 1·525; biaxial and apparently optically positive; probably selenite, but not crystallized in the usual manner."

The small quantity of hydrated Calcium sulphate present in these precipitates is undoubtedly derived from that in solution in the sea-water with which the media were made up, but the reason of its precipitation is difficult to explain since no such precipitation occurred in culture media kept uninoculated under similar conditions as control experiments. It would therefore appear that this deposition of Calcium sulphate, along with the Calcium carbonate, must in some indirect way be the result of bacterial action, and it would seem a possible suggestion that the odour of sulphuretted hydrogen noticeable in the deeper layers of the mud-flats might be due to the reduction of the Calcium sulphate to a sulphide and subsequent decomposition of the sulphide by bacterial action.

These observations have shown that on the chalky mud-flats of the Great Bahama Bank the *B. calcis* is found in enormous numbers, and also that this bacterium is capable of precipitating Calcium carbonate from fluid media containing soluble Calcium salts. It would seem a fair deduction that these mud-flats have been precipitated by the action of the *B. calcis* on the soluble Calcium salts carried into the sea by drainage from the land, where extensive and rapid weathering of the limestone rock is in progress.

CONCLUSION.

The observations so far available are too few, and the area they cover too small, to attempt to make any broad generalization at present. However, it can be stated with a fair degree of certainty that the very extensive chalky mud-flats forming the Great Bahama Bank, and those which are found in places in the neighbourhood of the Florida Keys, are now being precipitated by the action of the *Bacterium calcis* on the Calcium salts present in solution in sea-water. From this the suggestion is obvious that the *Bacterium calcis*, or other bacteria having a similar action, may have been an important factor in the formation of various chalk strata, in addition to the part played by the shells of foraminifera and other organisms in the formation of these rocks. Dr. T. Wayland Vaughan has also suggested that the Miami oölite, and other oölitic rocks, may owe their origin to the occurrence of some diagenetic change in the precipitate of very finely divided particles of Calcium carbonate, produced in this way by bacterial action. If this view as to the formation of chalk and oölite rocks is correct, it would seem probable that these strata must have been deposited in comparatively shallow seas, whose temperature approximated to that of tropical seas at the present time.

It has also been shown that bacterial denitrification is far more rapid and complete in the tropical seas round Jamaica, the Dry Tortugas, and the Bahamas, than in the temperate waters of the Bay of Biscay and the English Channel, and hence an explanation is provided of the relative scarcity of plankton and algal growth in the former localities, in accordance with the terms of Brandt's (2) hypothesis.

The distribution of the bacteria, both as to numbers and species, has been shown to vary at different localities and at different depths, but there are at present too few observations to enable any conclusions or generalizations to be drawn.

As it at present stands, the investigation can at most be considered to offer a mere indication of the part played by bacterial growth in the metabolism of the sea. To obtain a real insight into the question, it would be necessary to make more extensive bacterial and chemical observations in Tropical, Temperate, and Arctic waters, to study the bacteriology of other areas where Calcium carbonate is being precipitated from the sea, and to make further investigations in the Laboratory into the chemistry of the reactions that can be brought about by various species of marine bacteria.

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A Deep-sea Bacteriological Water-bottle.

By

Donald J. Matthews.

With Four Figures in the Text.

IN the past, deep-sea water samples for bacteriological purposes have been taken either by means of water-bottles provided with taps, and so made that the sample came in contact with metal, or in evacuated sterilized glass vessels drawn out to a fine point and sealed in the flame. The water-bottle is difficult to sterilize on account of the taps, and the results obtained are vitiated by the bactericidal action of metals.* The sealed glass tube is free from these defects, but at even moderate depths it is liable to collapse on the sudden change of pressure when the end of the capillary portion is broken off.

The water-bottle here described has none of these disadvantages, and has been used by Mr. G. H. Drew down to depths of 800 fathoms with complete success. It was designed and made at short notice, and time did not allow of more than one hurried trial before packing for shipment. Experience has shown since that many small alterations might be made which would render it more convenient, though not more accurate, in use; but as no opportunity of making and testing an improved model is likely to present itself in the near future, it is here shown in its original form.

The body of the water-bottle consists of a brass cylinder *a* of about 250 c.c. capacity, lined with a glass tube *b*. It moves freely by means of the guides *c* on the side frames *d*, which are made of brass rod and connected by circular plates *h* and *i*. Above and below the central cylinder are movable plates *e* and *f*, with recesses in which fit rubber washers, shown by shading. The washer plates and cylinder are pressed downwards by spiral springs *m* and *n* working against the fixed plate *g*, and can be held up against this pressure by two rods, only one of which, *l*, is shown in the section. The shorter rod, *l*, is fixed to the upper washer plate by a thread and lock nut which allow of a small vertical adjustment; it can be held up against the spring *m* by a bent lever bracketed on to the top plate (Fig. 3). The upper end of the

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* G. H. Drew on "The Precipitation of Calcium Carbonate in the Sea," etc. This Journal, Vol. IX, p. 479.

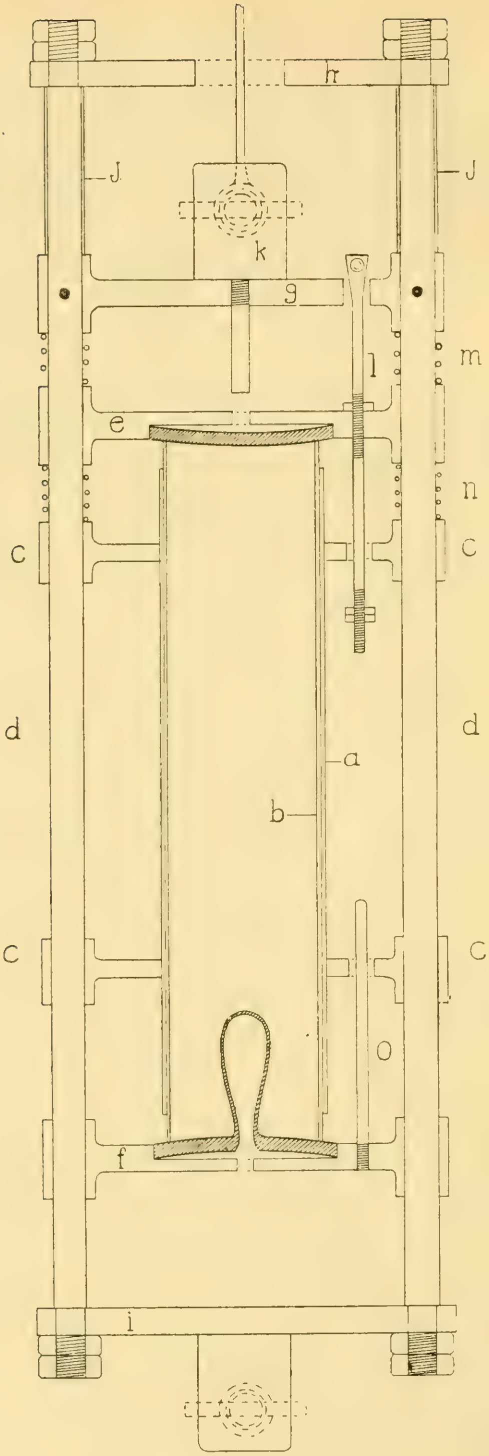
h
J
J
k
g
l
m
e
n
c
c
d
d
a
b
c
c
o
f
i

Fig. 1.

lever projects through the top plate ; a broad messenger dropped down the wire drives this projection downwards and disengages the lower end of the lever from the hole in the top of the short rod *l*, allowing the upper washer plate to fall. Another longer rod, not shown, is similarly fixed to the lower washer plate ; it passes freely through holes in the various plates and guides and engages with a second bent lever. The position of these two levers with respect to one another and the side frames is shown in Fig. 2. They project through the top plate at unequal distances from the centre, the inner one engaging with the long rod fastened to the lower washer plate. To prepare the water-bottle for use the lower washer plate is lifted slightly, so that it presses against the glass lining ; alcohol (95 %) is then poured in, and the cylinder further raised until it is closed by the upper washer ; the inner lever is now made to engage with the longer rod, and the outer one with the short rod *l* ; this closes the bottle tightly. It is now lowered to the required depth, and the first messenger (the inner, smaller one in Fig. 4) is dropped down the line. This disengages the lever holding up the longer rod, but is not wide enough to touch the other. The lower washer plate falls to the bottom of the frame, and the cylinder also falls, but not so far, until it is stopped by the lock nuts on the lower end of the rod *l*. It is now open widely at each end,

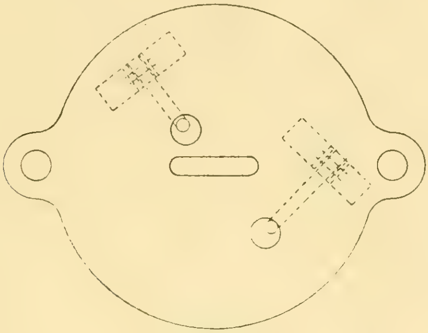

Fig. 2.

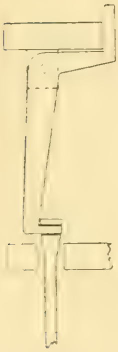

Fig. 3.

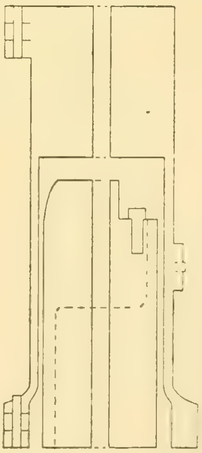

Fig. 4.

and the alcohol is displaced by the water. The second messenger, which is hollowed out below so as to pass over the first, is allowed to fall down the wire, and its broad base strikes the lever holding up the shorter rod. This allows the upper washer plate to fall on to the top of the cylinder, and the spiral springs keep the bottle tightly closed. It is now hauled up and a sample removed by a sterilized rubber tube.

The bottle is designed for use on a stranded steel wire, in the end of which an eye is spliced. Through this eye passes a screw threaded through two projections *k* shown on the upper side of the fixed plate *g*. The whole of the weight of the bottle and of any apparatus below it falls on this plate, so brass sleeves *j* are fitted on to the frames below the top plate to assist in taking the strain. A similar pair of cheeks with a screw is fitted to the bottom plate to permit of other apparatus being attached below.

At *o* is shown a rod which when the bottle opens drops till it is flush with the lower plate *c*. A loop of wire slipped over this makes it possible to release a reversing thermometer frame hanging below the bottle, or a messenger to actuate other apparatus.

The great defects to which water-bottles are liable are leakage and closing at the wrong moment. During descent leakage inwards might easily take place as the alcohol contracts on account of falling temperature and rising pressure. To counteract this, the lower washer has been made with a large dilatation ending blindly inwards but open to the sea at the other end; this would stretch slightly and compensate for the change of volume to a certain extent. It seems, however, to have been an unnecessary precaution. Leakage inward would be so small that the alcohol would remain strong enough to kill any bacteria which might enter, and could not affect the salinity of the sample, as the water-bottle is thoroughly washed out when the first messenger falls. Indeed, the escape of the alcohol is so rapid that at a short distance below the surface the sudden precipitation of the salts to which it gives rise has the appearance of an explosion. Leakage during hauling up would be outwards, and a pumping tendency by the rubber washers is not likely, as the water-bottle is closed by springs and not by weights.

That the water-bottle neither leaks nor closes at the wrong time is shown * clearly by the sharp fall in the number of bacteria below a certain depth, by the close agreement between the salinity at 400 fathoms at neighbouring stations, and by the agreement between the salinities at the greatest depth at which it has been used and those found by the *Michael Sars* at the same depth during her cruise in the

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* Drew, loc. cit.

North Atlantic in 1910. There has been no reason to doubt any of the results obtained with it, and on the single occasion when it failed to close it appears to have been lying on the bottom. It is true that at one station the results are decidedly difficult to explain, but in this case the weather made it necessary to keep the boat moving ahead while the water-bottle was out, and the depth actually reached is problematical; the stray was so great that at the time it was estimated that it might be only half that shown by the amount of wire out.

Various improvements might be made which would add considerably to the convenience of the water-bottle. In particular, the releasing rods should be arranged centrally, by means of elbows in the case of the longer one. As at present made, the supporting rods are placed asymmetrically with regard to the springs, and there is consequently a twisting moment which tends to jamb the guides on the frames; this can be prevented at present only by a very careful adjustment of the strength of the various springs.

The larger messenger is also somewhat unsatisfactory; in spite of numerous holes bored in its lower half to allow the water to escape, it takes about half an hour to fall through 800 fathoms, and at the same time it oscillates from side to side so violently that the wire quickly wears out the central hole to a funnel shape.

The Echinoderms collected by the "Huxley" from the North Side of the Bay of Biscay in August, 1906.

By

W. De Morgan.

My thanks are due to Dr. Allen for permitting me to examine this collection.

In all 292 specimens were obtained, but of these 16 were young immature Asteroidea and Echinoidea. It is impossible to identify these with any degree of certainty, and I have not hazarded an opinion about them.

The remainder belong to 17 genera and 24 species. The Ophiuroidea were particularly numerous, 190 specimens belonging to that class.

The classification followed is that of Professor MacBride in the Cambridge Natural History.

ASTEROIDEA.

Fam. ASTERINIDÆ.

Palmipes placenta (Pennant).

Station V. One specimen. 109 fathoms.
Bottom coarse sand and shells.

Fam. PENTAGONASTERIDÆ.

Dorigona subspinosa (Perrier).

Pentagonaster subspinosus. E. Perrier. *Bull. Mus. Comp. Zoology,* Vol. IX, No. 1, p. 21. 1881.

Pentagonaster subspinosus. E. Perrier. *Nouv. Arch. du Mus. d'Histoire Naturelle,* t. VI, p. 234. Pl. VI, Fig. 1. 1884.

Nymphaster protentus. Sladen. *Challenger* Reports, Vol. XXX, p. 203. Pl. L, Figs. 3 and 4. Pl. LIII, Figs. 9 and 10. 1889.

Nymphaster subspinosus. Bell. *Catalogue of British Echinoderms in British Museum,* p. 75. 1892.

Nymphaster subspinosus. Norman in Bourne. *Journal Marine Biological Association,* Vol. I, p. 327. 1890.

Dorigona subspinosa. E. Perrier. *Travailleur et Talisman.* Echinoderms, p. 375. 1896.

STATION XIII. One specimen. 412 fathoms.

A fine specimen. R = 102 mm., r = 25 mm. Breadth at base of arm 16 mm. Very few pedicellariæ. Colour in alcohol, light biscuit-brown.

FAM. ASTERIIDÆ.

Asterias rubens, Linnæus.

STATION II. One specimen. 75 fathoms.

OPHIUROIDEA.

FAM. OPHIOLEPIDIDÆ.

Ophiura ciliaris, Linn.

STATION V.	109 fathoms.	60 specimens.
STATION IX.	240 fathoms.	6 specimens.
STATION XII.	246 fathoms.	3 specimens.

The specimens dredged from Stations IX and XII are small, the largest having a disc only 5 mm. in diameter. They are remarkable for the thick cushion-like appearance of the discs, which were very convex above, and 2½ to 3 mm. thick. This may be due to their removal from a considerable depth.

Ophiura albida, Forbes.

STATION I.	75 fathoms.	1 specimen.
STATION II.	75 fathoms.	1 specimen.
STATION V.	109 fathoms.	1 specimen.

Ophiura affinis, Lütken, 1859.

Ophiura Grubei. Heller. *SB. AK. Wien,* XLVI, p. 431. Pl. II, Figs. 13–16. 1863.

Ophiura Normani. Hodge. *Trans. Tynes. Nat. Field Club,* V, p. 296. Pl. XVI. 1863.

Ophioglypha affinis. Lyman. *Ill. Cat. Mus. C.Z.*, I, p. 52. 1865.

Ophioglypha affinis. Lyman. *Chall. Rep. Oph.*, p. 77. 1882.

Ophiura affinis. Bell. *Brit. Mus. Cat.*, p. 111. 1892.

STATION I.	75 fathoms.	1 specimen.
STATION II.	75 fathoms.	15 specimens.
STATION V.	109 fathoms.	14 specimens.
STATION XI.	146 fathoms.	4 specimens.
STATION XII.	246 fathoms.	2 specimens.

The diameters of the discs measured dry were as follows :—

STATION I.	1 (6 mm.).
STATION II.	3 (2 mm.), 1 (2·5), 1 (3), 2 (5), 2 (5·5), 4 (6), 1 (6·5) mm.
STATION V.	1 (2), 1 (4), 2 (6·5), 4 (7), 3 (7·5), 2 (8), 1 (8·5), 1 (9) mm.
STATION XI.	2 (3), 2 (4·5) mm.
STATION XII.	1 (5), 1 (6) mm.

One specimen is recorded from Plymouth (*Journal M.B.A.*, Vol. V, N.S., 1897–9). This was from Bolt Head shell gravel ground. It agrees in all respects with the *Huxley* specimens. Diameter of disc, 4·5 mm.

Four specimens were also obtained from a collection made in the English Channel by Mr. Crawshay, at Station V, 20 miles S. 19° W. of the Eddystone (*Jour. Mar. Bio. Assoc.*, IX, p. 336). The discs of these measure 7, 6, 6, and 3·5 mm. in diameter, and in other respects they are similar to the *Huxley* specimens.

In all the above specimens the number of lateral spines is constant, namely three. The uppermost spine is the longest, and reaches halfway up the next dorsal plate of the ray. This exactly agrees with Lütken's description. Heller also states that there are three lateral spines.

Hodge (**5**), however, states that there are five lateral spines, and Jeffrey Bell (**1**) " about five."

Jeffrey Bell (**1**) describes as a " very small species."

Hodge (**5**) says that the disc " in well-grown individuals measures about ¼ inch."

Lütken says that it is 5 to 6 mm. in diameter.

The *Huxley* specimens show that it grows to a much larger size. The largest dried specimen from Station V, 109 fathoms, was 9 mm. diameter.

In descriptions of *Ophiura affinis* emphasis is laid on the regular rosulation of the primary plates. Judging from the *Huxley* specimens this is true only of the smaller and presumably younger individuals. In these there is a distinct rosette, consisting of a central and five surrounding plates, separated by smaller scales. As the animals increase in size the arrangement of the plates is not so regular, and they increase in number. Generally, however, indications of the primary arrangement may be traced.

The arm combs have a variable number of spines. In some specimens there were twelve on each side. On each side of the notch there are a variable number of small spinules, sometimes six on each side; and in the centre of the notch a small cluster. There may be a variable number of spines on the first upper arm-plate. Occasionally there is a complete row on each side of the arm-plate, which in continuation with those on the sides and centre of the notch form a complete curve of spinules. The arrangement is very variable, but the notch and arm-plate never appear to be quite destitute of spines.

In the *Huxley* collection, and other spirit-preserved specimens examined, the arms are banded at regular intervals with a darker shade.

Ophioconis Forbesi (Heller).

STATION V. 109 fathoms. 1 specimen.

The disc is rather distorted, but the diameter would be about 6 mm.

Ophioconis Forbesi is described as *Pectinura Forbesi* by Heller in *Untersuchungen über die Litoralfauna des adriatischen Meeres. Kaiserlischen Akad. der Wissenschaften.* 1862. Vol. XLVI, p. 423. Pl. II, Figs. 5–8.

See also Lütken, *Additamenta ad historiam Ophiuridarum*, Part III, p. 98. 1869.

AMPHIURIDÆ.

Amphiura elegans (Leach).

STATION I. 75 fathoms. 5 specimens.
STATION V. 109 fathoms. 6 specimens.

Ophiactis Balli (Thompson).

STATION I. 75 fathoms. 1 specimen.
STATION VII. 444 fathoms. 4 specimens.
STATION XIII. 412 fathoms. 6 specimens.

Ophiactis abyssicola (Sars).

Amphiura abyssicola. Sars. *Norg. Ech.* (1361), p. 18. Pl. II, Figs. 7–12.

Ophiocnida abyssicola. Lyman. *Ill. Cat. Mus. C.Z.*, I. 1865, p. 12.

Ophiactis abyssicola. Bell. *Brit. Mus. Cat. Echinoderms*, p. 123.

Station VII. 444 fathoms. 5 specimens.

Bell describes it as a rather small species. The two largest *Huxley* dried specimens have a disc diameter about 5 mm.

It is at once distinguishable from *Ophiactis Balli* by the unequal thickened disc scales and spines, and the large radial plates.

Ophiacantha abyssicola, G. O. Sars.

Station XII. 246 fathoms. 17 specimens.
Station XIII. 412 fathoms. 3 specimens.

All are young animals. The largest has a disc 5·5 mm. diameter, and arm 20 mm. long, as nearly as could be measured on a dry specimen. Bell (**1**) describes *abyssicola* as " a small species."

Diameter of disc 9 mm., and R said to =10 r. *O. abyssicola* has been obtained by the *Travailleur et Talisman* Expedition (**6**), p. 288, between Lat. N. 35° 42′, Long. W. 8° 40′, and Lat. N. 44° 5′, Long. W. 9° 25′ 40″ in depths from 112 to 1226 metres, and by the *Caudan* Expedition between Lat. 45° 57′, Long. 6° 41′, and Lat. 46° 40′, Long. 6° 58′ in 400 to 1700 metres. Koehler remarks (**6**) that all these specimens are identical with those from the coasts of Norway.

Bell (**1**) makes the translucency of the arm spines the key of the species, and this characteristic and the moniliform appearance of the arms is very marked in the *Huxley* specimens.

Grieg (**3**) remarks that *O. abyssicola* seems to be subject to sundry small variations as regards the spines on the disc, the aculeation of the branchial spikes, and their number, which is variable, and should not, in his opinion, be regarded as specifically diagnostic.

The spinulation of these young specimens is worthy of note. Both the dorsal and ventral surfaces of the disc are covered with thin subcircular imbricated scales. All the dorsal scales bear a knob or granule crowned with two to six very fine thorns. These thorny knobs are not present on all the ventral scales. As the disc increases in size the thorns grow longer, but the basal knob or granule remains about the same size. As the disc increases in size the thorns appear to coalesce into a single longer aculeated spine. This spine is much constricted at the proximal end, and easily breaks off from the knob. In the adult probably all the longer spines ultimately break off, leaving the disc covered with knobs or granules, as figured by Grieg. I have observed similar changes in *Ophiactis Balli*, and they are probably common to other Ophiurids.

Ophiacantha bidentata, Retzius.

Asterias bidentata. Retzius, 1805.

Ophiura Retzii. Nilsson, 1817.

Ophiocoma arctica. *M. Troj. Syst. Ast.*, 1842.

Ophiocoma echinulata. Forbes, 1852.

Ophiacantha Grœnlandica. *M. Tr. Arch. f. Nat.*, 1844.

Ophiacantha spinulosa. Sars, *Norg. Ech.*, 1861.

Ophiacantha spinulosa. Lyman, *Ill. Cat. Mus. C.Z.*, I., 1865, p. 93 and figure.

Ophiacantha bidentata. Jeffrey Bell, *Cat. Brit. Mus.*, p. 127.

STATION VII. 444 fathoms. 9 specimens.
STATION X. 146 fathoms. 10 specimens.

O. bidentata was taken by the *Talisman et Travailleur* Expedition between Lat. 19° 19′, Long. 20° 20′, and Lat. 39° 33′, Long. 12° 11′ 30″ in depths from 1965 to 2590 metres. All the specimens were small, the largest not more than 9 mm. diameter.

It was found by the *Caudan* Expedition in Lat. 45° 47′, Long. 6° 15′ in 17 metres.

The largest of the *Huxley* specimens has a disc diameter of only 5·5 mm., and the others are considerably smaller. Bell (**1**) gives the disc diameter as 13 mm. The *Huxley* specimens are therefore probably all young and immature. Descriptions of the species vary in certain points.

Bell (**1**) describes the mouth papillæ as "not numerous," but inconstant in number, and to some extent in position, as is the mouth shield in form. The disc covered with very short spines.

Lyman (**8**) gives *O. spinulosa* as the type of the genus, as its special mark "Disc evenly covered with short spines." The mouth papillæ, however, he describes as "standing well apart; six or seven to each angle of the mouth—two outermost on each side small, flattened, somewhat rounded, blunt; innermost one sharp, conical, rounded, resembling the lowest tooth, which also might be well enough considered as a mouth papilla. Teeth seven." The *Huxley* specimens agree in all these points, except that there are only four teeth. This might be accounted for by their age.

Lütken (**7**) describes and figures *O. bidentata.* The *Huxley* specimens agree with the figure, except in the magnified appearance of the spines. In the *Huxley* specimens the dorsal and ventral faces of the disc are covered with short, smooth, cylindrical spines, in some cases bifurcated. They stand on a slightly thorny stump or grain.

The plane of junction between the stump and the cylindrical spine is constricted, so that the spine might easily be brushed off the grain, as in the case of *O. abyssicola*. There is no indication of scales on the disc as in *O. abyssicola*, and the spines are equally thick on the ventral and dorsal surfaces.

Considering the immaturity of the specimens, and the variability of spinulation in young ophiurids, it would be rash to finally diagnose these as *O. bidentata*, but their general appearance makes it probable that they belong to that species.

OPHIOCOMIDÆ.

Ophiocoma nigra, O. F. Müller.

Station VII.	$\overline{4\dot{4}4}$ fathoms.	18 specimens.

ECHINOIDEA.

Cidaridæ.

Cidaris papillata (Leske), 1778.

Station XI.	146 fathoms.	17 specimens.
Station XII.	246 fathoms.	14 specimens.
Station XIII.	412 fathoms.	19 specimens.

ECHINOTHURIIDÆ.

Phormosoma luculentum, Agassiz.

Station XII.	246 fathoms.	1 specimen.
Station XIII.	412 fathoms.	3 specimens.

This species is described and figured by A. Agassiz in his report on the *Echinoidea*. The voyage of H.M.S. *Challenger*, Vol. III, p. 97, Pls. IX, X, Xa, Figs. 3–7; Pl. XXXIX, Fig. 8; Pl. XL, Figs. 31–36; Pl. XLIV, Figs. 25–27.

It was obtained by the *Caudan* Expedition (**6a**), and in the N. Atlantic by the *Hirondelle*.

ECHINIDÆ.

Echinus norvegicus, Düb. o. Kor, 1844.

Station V.	109 fathoms.	1 specimen.
Station VII.	$\overline{4\dot{4}4}$ fathoms.	1 specimen.
Station XII.	246 fathoms.	3 specimens.

These are young animals. The measurements of the largest taken at Station XII are: Diameter of test, 13·5 mm.; height of test, 7·5 mm.; length of longest spine, 13 mm.

Although collected three years ago, preserved in spirit, and dried, the red patches on the test are quite clear in the larger specimens.

CLYPEASTROIDEA.

Fibularidæ.

Echinocyamus pusillus, O. F. Müller.

Station XII. 246 fathoms. 2 specimens.

SPATANGOIDEA.

Spatangidæ.

Spatangus purpureus (O. F. Müller).

Station II. 2 specimens.
Station XII. 246 fathoms. 2 specimens.

Spatangus Raschi (Loven).

Station IX. 240 fathoms. 30 specimens.

Echinocardium pennatifidum, Norman.

Station XI. 146 fathoms. 4 specimens.

HOLOTHUROIDEA.

ASPIDOCHIROTA.

Fam. HOLOTHURIIDÆ.

Stichopus tremulus. Gunnerus (Östergren).
Stichopus Richardi. Hérouard.
Stichopus Richardi. R. Perrier.
Holothuria tremula. Gunnerus. 1767. Düben and Koren, Sars, Théel, Jeffrey Bell.
Holothuria elegans. F. O. Müller, Jäger, Brandt.

Station IX. 240 fathoms. 7 specimens.
Station XII. 246 fathoms. 1 specimen.

Up to 1896 this species was regarded as a true Holothurian, possessing only one bundle of genital tubes. In 1896, Östergren (**9**) demonstrated that it has two bundles of genital tubes, and consequently, as a true Stichopus, should be called *Stichopus tremulus.*

R. Perrier, in his examination of the Holothurians of the *Talisman* *et Travailleur* Expedition, also recognized the two bundles of genital tubes (**10**), p. 485, and included his specimens in the genus Stichopus.

Hérouard (**4**), p. 8, described what he thought to be a new species under the name of *Stichopus Richardi.* R. Perrier (**11**) called attention to the resemblance between this new species and *Holothuria tremula*, and also how it differed in the arrangement of the ambulacra, and in possessing two bundles of genital tubes. Perrier then read Östergren's work, and concluded that *Stichopus Richardi* and *Stichopus tremulus* are identical.

He then made certain additions to Östergren's description, and gives figures of the sclerites. Hérouard (**4**), Pl. VIII, gives drawings of the sclerites of *Stichopus Richardi* which agree with Perrier's. He, however, does not figure the "spire" (or "tige," as Perrier has it) of the disc, which is very characteristic.

The *Huxley* specimens agree with Perrier's description of *Stichopus tremulus* in external form, in the shape of the sclerites, and in possessing two bundles of genital tubes, one on each side of the dorsal mesentery. Both Théel (**12**) and Jeffrey Bell (**1**) make the absence of C-shaped deposits characteristic of *Holothuria.* Perrier describes arciform spicules in the ambulacral papillæ, and in the ventral feet of *Stichopus tremulus*, and such arciform spicules appear in the *Huxley* specimens, some being sufficiently curved to warrant the description C spicules.

These specimens have been some years in spirit, but in places a faint rosy tinge is still discernible.

Stichopus regalis (Cuvier).

Holothuria columnæ. Cuvier. 1817.
Holothuria triquetra. Della Chiaje. 1828.

Station XI. 146 fathoms. 1 specimen.

Stichopus regalis is easily recognized by the flattened ventral surface, and the well-marked division between that and the slightly convex dorsal surface. The discs of the tables also are very characteristic. They have a fairly unbroken margin, and want the sharp marginal teeth found in *Stichopus tremulus.* They are perforated by numerous holes, Théel (**12**).

Perrier's (**11**) description is very similar. He states that in young specimens the four rods are longer in proportion to the diameter of the basal disc, and are more convergent at the top. Also that in young specimens, the four rods are smooth, and end in a point, while "chez les adults elles sont hérisées de dents à leur extremité et aussi sur une certaine longueur au-dessous de cette extremité."

In the *Huxley* specimen some of the discs have 54 perforations, the average being about 44.

This specimen, which has been three years in spirit, still gives a very fair notion of the colour as described by Perrier.

CRINOIDEA.

Comatulidæ.

Antedon bifida (Pennant = rosacea).

STATION V. 109 fathoms. 2 specimens.

Antedon flava, Koehler.

STATION XIII. 412 fathoms. 2 specimens.

I am indebted to Dr. Koehler, of Lyons, for identifying this species.

Two specimens were obtained by the *Caudan* Expedition from a depth of 1410 metres, and it is described and figured (**6a**), p. 9, Figs. 20 and 21.

Actinometra pulchella. Pourtalès.

Antedon alata. Pourtalès, *Bull. Mus. C.Z.*, 1878, Vol. V, No. 9, 215.

Antedon pulchella. Pourtalès, *ib.*, 216.

Actinometra pulchella. 1881. P. H. Carpenter, *ib.*, Vol. IX, 4, p. 10.

Actinometra pulchella. 1888. P. H. Carpenter, *Challenger* Reports, Vol. XXVI, p. 304, Pl. IV., LII.

Actinometra pulchella. 1896. Koehler, *Campagne du Caudan*, p. 100.

STATION VII. $\frac{}{444}$ fathoms. 2 imperfect specimens.

STATION XIII. 412 fathoms. 15 specimens, of which two are good, the others badly mutilated.

This species was obtained by the *Blake* [Carpenter (**2**)], at a great number of stations, but at depths nowhere over 300 fathoms and rarely exceeding 200 fathoms. The *Porcupine* specimens were dredged at 477 fathoms and those of the *Dacia* at 533 fathoms. The *Caudan* specimens were from depths varying from 400 to 1710 metres.

Except two species of Rhizocrinus, this is the only Crinoid common to the European and Caribbean seas, and the only European species of *Actinometra*.

LIST OF SPECIES AND STATIONS AT WHICH THEY OCCURRED.

Station No.	I	II	V	VI	VII	IX	X	XI	XII	XIII
Latitude, N.	48° 25′	48° 24′	47° 48′	47° 46′	47° 36′	48° 7′	48° 7′	48° 10′	48° 7½′	48° 7½′
Longitude, W.	6° 28′	6° 28′	7° 46′	7° 46′	7° 31′	8° 13′	8° 13′	8° 11′	8° 13′	8° 13′
Depth in fathoms	75	75	109	—	444	240	146	146	246	412
Bottom Deposit.	—	—	Coarse sand and shells.	—	—	Fine sand.	Fine sand.	Fine sand.	Fine sand.	Sand, mud, and hard ground.
Palmipes placenta	...	...	1	...	...	...	...	...	...	...
Dorigona subspinosa	...	...	...	...	...	...	...	...	...	1
Asterias rubens	...	1	...	...	...	...	...	...	...	...
Ophiura ciliaris	...	...	60	...	...	6	...	...	3	...
Ophiura albida	1	1	1	...	...	...	...	...	...	...
Ophiura affinis	1	15	14	...	...	...	...	4	2	...
Ophioconis Forbesi	...	...	1	...	...	...	...	...	...	...
Amphiura elegans	5	...	6	...	...	...	...	...	...	...
Ophiactis Balli	1	...	...	...	4	...	...	...	...	6
Ophiactis abyssicola	...	...	...	...	5	...	...	...	...	...
Ophiacantha abyssicola	...	...	...	...	...	...	...	...	17	3
Ophiacantha bidentata	...	...	...	...	9	...	10	...	...	...
Ophiocoma nigra	...	...	...	...	18	...	...	...	...	...
Cidaris papillata	...	...	...	...	...	...	...	17	14	19
Phormosoma luculentum	...	...	...	...	...	...	...	...	1	3
Echinus norvegicus	...	...	1	..	1	...	...	...	3	...
Echinocyamus pusillus	...	...	...	...	...	...	...	...	2	...
Spatangus purpureus	...	2	...	...	...	...	...	...	2	...
Spatangus Raschi	...	...	...	...	...	30	...	...	...	...
Echinocardium pennatifidum	...	...	...	...	...	...	...	4	...	...
Stichopus regalis	...	..	...	...	...	...	...	1	...	...
Stichopus tremula	...	...	...	...	...	7	...	...	1	...
Antedon bifida	...	...	2	...	...	...	...	...	...	...
Antedon flava	...	...	...	...	...	...	...	...	...	2
Actinometra pulchella	...	...	...	..	2	...	...	...	...	15
Young forms "incertæ sedis":										
Asteroidea	...	. .	...	...	4	...	...	...	1	4
Echinoidea	...	...	...	...	...	...	...	...	7	...

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Description of a New Species of Brackish-water *Gammarus* (*G. chevreuxi*, n. sp.).

By

E. W. Sexton.

With Five Figures in the Text.

THE *Gammarus* here described is found in Chelson Meadow, a large tract of reclaimed land lying near the mouth of the Plym, and protected from the tidal water by an embankment. The land is drained by ditches, which empty into the Plym at low water by means of sluice-gates. The sea-water enters in volume only at the highest tides over the top of the sluice-gates, but there is a constant slight infiltration of salt water through the embankment.

I have named the species in honour of M. Edouard Chevreux, who has always assisted me most generously with his knowledge of the group as well as with specimens from his collection.

Gammarus chevreuxi resembles *G. locusta* more nearly than any of the other species of the genus, but there are certain constant characters, e.g. in the antennae, the fourth sideplates, the third uropods, etc., which seem to me of sufficient specific value to justify its establishment as a separate species.

DESCRIPTION.

Gammarus chevreuxi is a small species, the largest male measuring 13 mm. in length, and the largest female 9 mm.

The animals are delicate in appearance, and so transparent that their internal organs show plainly through the cuticle.

The *cuticle* in both sexes has a remarkable sensory armature, that of the pleon in particular. All the pleon-segments are covered with microscopic spinules, longest and densest dorsally. Segments 1 to 4 are the most spinose; the spinules of segments 5 and 6 are shorter and finer. The cuticle of the peraeon is not produced in spinules, but has a surface like a fine file, the head and anterior segments being the smoothest. All over the body are scattered microscopic sensory cleft-tipped hairs, each hair set in a little pocket in the skin, some single, some in rows of four to six. Each peraeon-segment carries one of these rows in the median line; pleon-segments 4 to 6 each have at least three of these rows in line with the usual spine-clusters characteristic of the genus; and the telson has two rows, one on each side.

Sideplates rather small; the fourth (Fig. 1) forms one of the distinguishing specific characters. The posterior expansion is produced downwards, but not nearly as much as in *G. locusta;* it rounds into the inferior margin, and has two setae inset.

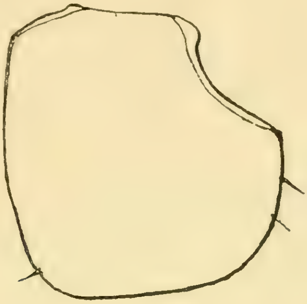

FIG. 1.—Sideplate 4. ♂ *Gammarus chevreuxi*, n. sp. ×27.

Pleon. Hind margin of segments 2 and 3 straight, with a few setules inset, postero-lateral corners produced to a short acute angle. Segments 4 to 6 rounded dorsally, 5 and 6 very short; the dorsal spine-clusters of these segments have each two divergent spines; the lateral clusters usually with two or three spines and a few hairs in each cluster.

Head. Lateral lobes not much produced, truncate, upper angle obtuse, rounded below; sinus rather deep; post-antennal angle produced, subacute.

Eyes reniform; pigment usually black coated with white, but occasionally a few individuals are found in a brood with red pigment instead of black.

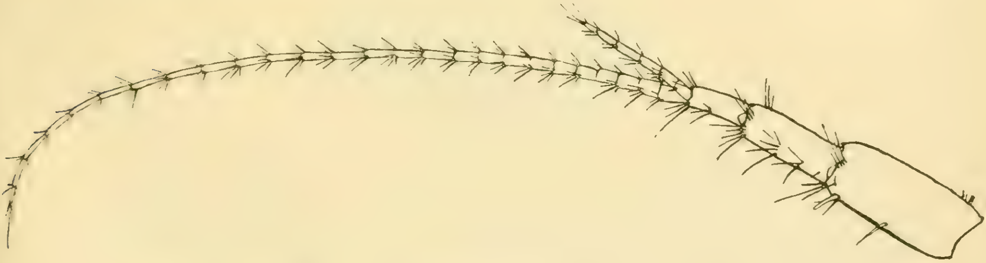

FIG. 2.—Antenna 1. ♂ *Gammarus chevreuxi*, n. sp. Inner side. ×27.

Antenna 1 (Fig. 2). The first joint of the peduncle is about equal in length to the second and third taken together. The number of joints in the flagella varies with age and sex; one of the largest males had thirty-five in the primary flagellum and seven in the accessory.

A large female had twenty in the one and four in the other, the flagella being shorter and more setose than in the male.

Antenna 2 (Fig. 3) of the male forms one of the distinguishing characters of this species, easily separating it from the other species of *Gammarus.* The fourth and fifth joints of the peduncle and the flagellum (excepting the four terminal joints) are clothed on the inner surface as well as on the inferior margin with dense tufts of long exceedingly fine sensory hairs. These hairs have very delicate coiled tips and are found only in the male, on the second antennae, the gnathopods, the first peraeopods, the third uropods, and the telson. The flagellum in the male is sixteen-jointed. The female has only a few clusters of long outstanding straight setae on the fourth and fifth joints of the peduncle, and short setae on the flagellum.

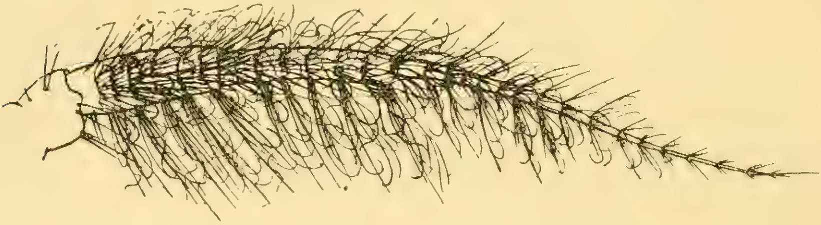

FIG. 3.—Antenna 2. ♂ *Gammarus chevreuxi*, n. sp. Inner side. × 27.

Gnathopods 1 and 2 rather small, not much difference in their size. In the male, Gnath. 1 (Fig. 4) has the sixth joint pyriform, palm oblique, indented, with one stout truncate spine midway on the palmar margin, angle defined by spines; finger much curved, impinging against the inner surface of the hand. In Gnath. 2 (Fig. 5) the hand is broader, palm slightly oblique. In both gnathopods the hand, especially on the inner side, is provided with numbers of the coiled sensory hairs, the fifth joint also carrying a few.

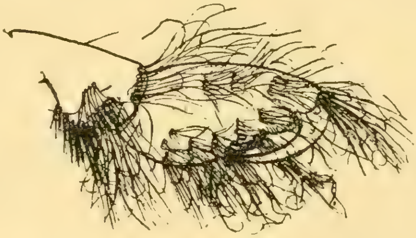

FIG. 4.—Gnathopod 1. ♂ *Gammarus chevreuxi*, n. sp. Inner side. × 27.

In the female the fifth and sixth joints of Gnath. 1 are practically subequal in length, but the fifth is much wider distally than the sixth;

palm slightly oblique, palmar margin crenulate and beset with small sensory spines, palmar angle with one long and two short spines on the outer side, and one long and one short on the inner. In Gnath. 2 the fifth and sixth joints are equal in length and of equal width throughout, both provided posteriorly with clusters of straight setae, palm transverse, with the margin rounded, and spines as in Gnath. 1.

Peraeopod 1 in the male has the posterior margins of the fourth, fifth, and sixth joints beset with clusters of the sensory coiled hairs.

Peraeopod 3 elongate, the hind expansion of the basal joint lightly crenulate, hind lobe free. Peraeopods 4 and 5 not much longer than pp. 3; the basal joint expanded above, gradually narrowing to the distal angle, where one or two strong spines are inset. In the female these joints, especially that of the fifth, differ in shape from those of the male; they are expanded above, but about two-thirds down they suddenly narrow; several long plumose hairs are inset on the inner side. All the hinder peraeopods are furnished with spines, most numerous on the fifth.

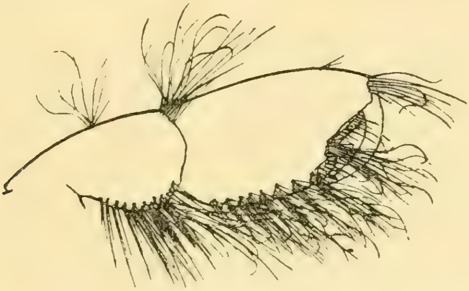

FIG. 5.—Gnathopod 2. ♂ *Gammarus chevreuxi*, n. sp. Outer side. ×27.

The *incubatory lamellae* occur on segments 2 to 5.

The *branchial vesicles* are on segments 2 to 7; they are borne on stalks, are ovate in form, and densely fringed with tangled hairs round the tip and along the posterior margin, especially in the male.

Uropods. The first pair extend beyond the second. In the third the inner ramus is not much more than a half the length of the outer, both thickly beset in the male with tufts of the characteristic sensory hairs, intermixed with long straight setae. This pair of uropods is shorter in the female, and is furnished with long spines and straight and feathered setae.

The *telson* has an apical group of three spines; of the two lateral groups the upper one carries two spines and one or two setae, and the other one spine and one or two setae.

Notes on the Life History of *Gammarus chevreuxi*

By

E. W. Sexton and Annie Matthews, M.Sc.

INTRODUCTION.

The present paper is the outcome of an investigation made on a species of *Gammarus* inhabiting both fresh and brackish water (4, p. 657). As this species (*G. zaddachi*) seemed to show a marked variation in appearance according to its environment, we instituted experiments in the Laboratory at Plymouth on *G. chevreuxi* to see if a similar variation in appearance could be brought about by varying the degree of salinity of the water in which the animals lived.

It would have been impossible to have obtained any measure of success without the kind co-operation of Dr. Allen, and we wish here to acknowledge our indebtedness to him, and to the various members of the staff for their continual and willing help.

Our ultimate object, which is to establish if possible a variation in the appearance of a given species by altering its environment, has had to stand over for a time, until other more pressing problems were settled. The first of these was how to ensure a constant supply of healthy animals, able to live and breed under Laboratory conditions, and the next was to find if it were possible to bring them to live in fresh water and in sea-water. In both of these experiments we have succeeded far better than we anticipated. We have now (January, 1913) the young of the *fifth* generation, bred from the animals captured in June; and, after some three months' gradual altering of the original water, we have some individuals living and breeding in absolutely fresh water, while others of the same stock are living and breeding in pure sea-water. Other problems in the life history have still to be worked out, this paper being intended only as a summary of the work as far as we have gone. Some of our conclusions will no doubt need revision later.

It must be remembered that the results here given are all obtained under artificial conditions. If it were simply a question of multiplying generations the conditions could have been made more like the natural surroundings, with stones, and plenty of mud and dirt provided for the shelter the animals seek when they moult, etc. Our method of work, however, necessitated daily observations being taken without unnecessary disturbance, and the bowls had therefore to be kept in the light, free from dirt and dust, and with only just sufficient ulva for food and not enough to provide a hiding-place.

We chose for our experiments the brackish-water *Gammarus chevreuxi*, as being easily obtainable in the neighbourhood. It occurs in the ditches draining Chelson Meadow (see previous paper).

GENERAL METHODS.

We brought our first specimens to the Laboratory on June 4 of last year (1912), together with some of the water, ulva, and the isopod *Sphaeroma serratum*, from the same ditch.

The next day two mated pairs were taken, and daily observations commenced. We kept these in jars partly covered to exclude dust, but a sufficient supply of air was ensured by a continuous bubbling of air through the water. We have found since that this is not essential, provided enough air can be supplied in some other way, such, for instance, as exposing a large surface of water to the air. In this way several broods have done well in large crystallizing dishes, about twelve inches across and two-thirds full of water, dust being excluded as in the jars. We consider, however, that we get better results, with the older animals at any rate, when the water is aerated.

With regard to the young, experience has shown us that the best method of observing them through their various stages to sexual maturity, and of obtaining their moults as they are cast, is to place each individual in a separate finger-bowl, half full of water, and almost wholly covered with a glass plate. The water is aerated once a day with a pipette, and a little ulva is given for food.

All the dishes and jars have been kept in ordinary diffused daylight, not protected in any way.

The temperature in the Laboratory in summer probably does not differ much from that in the ditches, but in winter it is considerably higher. It varies through a number of degrees at different times of the day and on different days. The animals, however, appear but little affected by this variation. The only point we have noticed is that the rate of development and the time of reaching sexual maturity are retarded by a lower temperature. In the Laboratory from October to December the temperature of the water in the moult-bowls varied between 10°–16° C.; in another room not artificially heated the range was from 4°–10° C. during the same period. In order to test the difference, if any, in the rate of moulting, a brood was divided, half being kept in the Laboratory and half in the other room, and it was found that some of the young took twice as long over their first moult in the colder place—in fact, some of those in the Laboratory had accomplished a second moult before all the young in the other room had finished their first.

The main food is ulva, supplemented by enteromorpha, and the rotting leaves of oak, beech, and sycamore. Certain kinds of animal food are eagerly taken, such as *Sphaeroma serratum* from the ditches in all stages of putrefaction, but this is a diet we give sparingly for fear of fouling the water.

Occasionally healthy males will attack and devour weak or sickly females, but they have not been seen eating dead ones. The animals will tear up their cast skins or "moults," and if these are not removed within, say, twenty-four hours, they will disappear completely. The inference is that they are eaten, and we feel sure this inference is correct, although we have no direct proof. It is certainly the case in other genera—two *Jassa*, for instance, were actually watched in the Laboratory devouring their skins immediately after ecdysis; and again, we have never found any torn pieces of a moult that has disappeared in the dirt pipetted daily out of the bowls.

Both male and female feed during the carrying period of the mating—not only cropping the ulva while resting on it, but holding pieces with their gnathopods while swimming. The young feed while in the incubatory pouch; their intestines are full when they emerge.

REPRODUCTION.

The conclusions arrived at by Holmes (3) and Embody (2) on the mating of Amphipods are, as we understand, as follows:—(1) that neither sight nor smell is concerned in the mating of a pair; (2) that they meet accidentally; and (3) that the female is wholly passive throughout, and indeed that the male recognizes her as a female by this passivity. Our results, as far as we have gone, indicate on the contrary that mating is not one-sided but mutual, and that a female when in the right physiological condition will at times seek the male, and, on the other hand, when not in this condition will actively resist him. The meeting of the sexes in the first place seems accidental, but the one certainly appreciates the presence of the other by the touching of the antennae. The antennae are provided with highly developed sensory organs, in which the olfactory sense may or may not be located, but we feel certain that in our species the animals always employ the antennae in meeting others, and in recognizing their own species.

Sexual maturity in both sexes is attained when the animals are about half grown. The time they take in reaching maturity varies greatly, but the cause of such variation is not yet known. The young produced in summer appear to become mature in much less time than those hatched later, but this cannot be laid down as a rule, as there is evidently some other potent factor at work besides temperature. The first brood of Pair I was extruded on June 19th and reached maturity on July 25th, i.e. in thirty-six days. Sometimes, however, a later brood will reach maturity before an earlier; for instance, Brood II of Pair II, extruded July 4th, did not reach maturity till September 4th, a period of sixty-two days, while Brood IV of the same pair, extruded July 29th, became mature on September 9th, only forty-two days.

The male takes the female when their respective gonads are becoming mature and carries her sometimes for days before mating takes place. This occurs once a fortnight with the female, so that, in ideal conditions, twenty-six broods could be produced annually. This would imply that breeding continues throughout the year, and such we believe to be the case, at any rate in a mild climate like Plymouth. It has gone on uninterruptedly in our jars during the seven months we have been working, from early in June to mid-January, and breeding pairs are still found in the ditches in Chelson Meadow.

The male, on the other hand, seems to have no regular mating period, but can fertilize a succession of females with an occasional period of rest. One young male, which became sexually mature on September 28th at the age of fifty-two days, by October 1st had fertilized the three females in the same jar. An interesting point to note is that the last female had only two eggs, and these were thrown off the next day, which may have been due to the fact that the eggs were not properly fertilized, and also suggests that the number of eggs extruded *may* bear some relation to the condition of the male. Again, in Brood I of Pair I a male and a female became mature in thirty-six days; four days later four other females were fertilized by this male and another, and again the last females mated had a small number of eggs, five and seven respectively, while the first female had eighteen. How many times in succession a male can mate we do not yet know, because we have never had a succession of females in the right condition. If a male is placed in a dish with several females whose eggs are at different stages of development, he chooses one with advanced eggs, mates with that one first, and then with the others in succession. If, however, he is placed with only one female, and that one with very young eggs, he does not attempt to take her until the eggs are five or six days old, and neither would the female permit herself to be carried by him till then. We have a few records of a male carrying a female for this length of time, eight or nine days before the young are extruded from the pouch, but he will only do it when there is no riper female present. The relative size of the male and female in mating does not seem of much importance; at times a big male will take a very small female, and vice versa.

We have watched the whole process of the moulting of the female, followed by fertilization and oviposition, and find that it is practically the same in our species as in *Gammarus pulex*, as described by Della Valle (1).

In the case watched, the last young one of the previous brood was extruded at 2 p.m. (December 14th, 1912), while the male was holding the female. They swam about together afterwards, stopping occasionally to seize and eat pieces of ulva.

A periodic convulsive movement on the part of the female, increasing in frequency and violence, led up to the casting of the skin at 7 p.m. the following day. Meanwhile the male employed not only the second gnathopods, but the first and second peraeopods as well in holding the female. At times the male arched himself, bringing the urosome up to rest against the fifth peraeon-segment of the female, and then suddenly straightened out, rasping the uropods along the female's cuticle. During the whole time the male kept the lower antennae bent over the head of the female, so touching both pairs of her antennae. About two hours before the moult the female commenced a series of violent rapid jerks, bringing the head and urosome together, and then straightening suddenly, at intervals stiffening the body in the form of a comma, with the head bent downwards, the body moving with a sort of convulsive tremor. Finally the male ceased swimming, and they both lay quiet, while the female, helped by the male, freed the head from the old cuticle with the gnathopods. This process and the ensuing rest occupied not more than five minutes. Then the male suddenly arched the body as before, and in straightening again pushed off the posterior portion of the moult with his uropods, assisted by the upward heaving of the female's body. He did not relinquish his hold for a moment. After moulting the female lay absolutely still, without even a movement of the pleopods, while the male kept up a steady current with his. In a few minutes they commenced to swim as before.

About an hour and a quarter after the moulting the male began to turn the female round, and after several efforts he succeeded in getting into the position described by Della Valle. At 8.30 p.m. the first ejection of sperm into the pouch was effected in four or five spasmodic movements. After lying quiet in this position for a minute or so, the male resumed the dorsal clasp, but five minutes later the whole process was repeated. Once more after an interval the male resumed the original dorsal position and swam again. After another five minutes—at 8.40 p.m.—the female suddenly struggled free, and did not allow the male to carry her again, darting away if he approached. Just at the moment they separated the first egg was seen emerging from the aperture of the oviduct. The last egg passed from the ovaries exactly twenty-four minutes later, and the newly extruded mass hung in the pouch in spheroidal form, the eggs held together by a glutinous secretion. The number of eggs was forty.

In another case watched, a distinct oviduct was apparent during the passage of each egg from the ovary to the exterior. This was clearly distinguishable as a thin light line only during the actual extrusion of the egg. The eggs laid first were pushed forward in the pouch by the later ones, and it may be mentioned here that the front ones were seen to hatch first.

The female *can* moult alone after extruding a brood from the pouch, so the presence of a male is not imperative for the moult, but our experience agrees with Embody's, that eggs are never deposited unless a male is present. In the absence of a male the eggs develop enormously in the ovaries, and are separated by distinct spaces, as happens during the normal development in the pouch, but what ultimately becomes of them has not yet been traced.

We have tried several experiments to determine the extreme interval that can elapse between any given moult and the subsequent oviposition, and we find that on the third day oviposition is still possible. If a male is kept away for four days or more after the female's moult, no mating occurs until the fourteenth day, i.e. until the next period begins, and such mating is preceded by a second moult.

It is evident that in the female moulting is directly connected with mating. The animal of course increases in size also, but as the moults occur at fortnightly intervals this increase is too gradual to be noticed at the time. With the male, on the contrary, moulting appears to be purely a growth process. The moults are at long intervals, and the increase in size very noticeable. The oldest male we have, extruded June 19th, became sexually mature July 25th, and has only been observed to moult three times since, on Aug. 1, Sept. 4, and Nov. 5.

The number of eggs in the broods we have counted varies between five and forty-four, about thirty being a fair average. The number seems to increase with age, as one would expect, e.g. one female increased the number gradually from eighteen to forty-four. The eggs when laid have the characteristic blackish-green colour of the ovary; about a week later they turn brown, then yellow, the body of the embryo being now distinctly visible. They are hatched about the twelfth to the fourteenth day, and the young are extruded from the pouch the day after. Discomfort will hasten the extrusion, e.g. irritation with a brush, lack of water, etc.

Our results show that the age of sexual maturity is from thirty-six days onward, but we are inclined to think the earlier age the more normal. Counting the time from oviposition, only fifty days, therefore, elapse between one generation and the next, and this period is probably less in the heat of summer. We have now (Jan. 2, 1913) after seven months, the young of the fifth generation.

THE YOUNG.

The young remain one day, or at the most two days, in the incubatory pouch after hatching. The four pairs of incubatory lamellae with their interlacing hairs form a continuous pouch except for a small aperture in front and one behind, where the lamellae are separated at the top by the width of the female's body. Through these apertures the young emerge, but the female can close the entrances at will by bending down her projecting mouth-parts, and by lateral compression with her gnathopods and peraeopods. At times some of the young come halfway out, others again creep right out at the back and crawl along her ventral surface between the bases of her hinder peraeopods, then suddenly double back and re-enter the pouch. But if once they get outside the peraeopods, the swirl set up by beating pleopods prevents their ever re-entering. They are exceedingly active when inside, changing places continually; when they are once out they swim vigorously, and if they meet a piece of ulva or anything that can serve as shelter they climb in and hide themselves.

We have noticed an occasional female with red eyes instead of black, among the adults. A small proportion of the newly hatched young also have red eyes, the rest of their colouring being normal.

We have been puzzled by a great difference in size among the individuals in any given brood. Sometimes this is apparent when they are first extruded, at other times some gain enormously in size while growing as compared with the others, and finally some members of a brood become sexually mature much earlier than others. It may be simply that the weaklings lag behind, but as the male and female differ so much in size at sexual maturity it may perhaps be a sexual distinction. The results of our experiments may clear this point later.

We have isolated 130 newly hatched young from different broods, and are collecting and numbering the moults as they occur. We hope when they attain sexual maturity to be able to trace back in the moults the changes undergone, and the sexual distinctions if any. Certainly the last moult before maturity shows sexual differentiation, for the female already has the incubatory lamellae present, though only partially developed, and the male has a few of the coiled sensory hairs on the antennae, telson, etc.

The time taken in the moulting of the young appears to be much shorter than with the adult. For a few days previous they are less active than usual, and a flocculent sediment is noticed in the bottom of the bowl. This, we think, is the secretion, probably lubricative, of which a copious flow precedes ecdysis, oozing from between the terga, and from all the joints of the antennae, the peraeopods, etc. Della Valle (**1**, p. 111) refers to this in describing the moulting of the female. Several young have been watched moulting; they used their anterior appendages in loosening the old cuticle of the head, but the whole process, pulling off the head covering and slipping out of the posterior portion of the cuticle, only occupied three or four seconds.

The first moult seems to be the most critical; in one brood fifteen out of thirty-two died during the first moult. Afterwards the mortality is comparatively small. Where the period between moults has been longer than normal, the individual is undersized and evidently weakly, in many cases not surviving the next ecdysis. Below are tabulated side by side the rate at which two broods moulted, kept under exactly the same conditions in the cold room. The right-hand table refers to a brood seven days younger than the other, and it will be seen that the rate of development was quicker in the younger brood. Number *d* in Brood I was much larger than the others when hatched, number *k* much smaller. This one did not grow perceptibly after its second moult, and died seventeen days later in the effort to moult again. Number *e* did not grow much after the second moult, and died just after its fourth moult. Number *i* took the longest time yet recorded for a third moult—twenty-six days; it is an exceedingly small specimen, and had great trouble in getting rid of the old cuticle.

BROOD I.

Extruded 5.11.1912.

Period in Days Between Moults.

	Moult 1.	Moult 2.	Moult 3.	Moult 4.	Moult 5.	Moult 6.
a	8	10	14	22	13	18
b	8	11	17	12	15	18
c	9	10	15	11	14	16
d	9	13	15	12	16	17
e	9	13	18	12 died directly after moult.		
f	10	10	14	8	11	14
g	10	10	15	14	14	
h	10	10	17	10	14	16
i	11	10	26	10 died in moulting.		
j	11	11	14	16	11	15
k	11	11	17 died in moulting.			
l	11	11 dead two days later.				
m	11	11 dead two days later.				
n	12	12 dead two days later.				
o	13	9	13	27 died in moulting.		
p	13	12	13	9	13	20
q	13	14 died in moulting.				

BROOD II.

Extruded 12.11.1912.

Period in Days Between Moults.

	Moult 1.	Moult	Moult 3.	Moult 4.	Moult 5.	Moult 6.
a	7	9	11	8	10	13
b	7	9	12	23	15	23
c	7	9	13	12	12	13
d	8	8	11	10	13 died in moulting.	
e	8	9	11	9	10 died directly after moult.	
f	8	9	11	15	16	17
g	8	10	11	22	11 died in moulting.	
h	8	10	12	12	12	16
i	8	14	10 dead nine days later. Very small.			
j	8	14	11	11	8 died in moulting.	
	8	14	15	15 died in moulting.		
l	8	16 died during moult.				
m	9	11	11	9	11	11
n	9	11	12	9	17	19
o	9	13	8	9	9	11
p	9	13	12	11	11 very small one.	
q	10	13	9	24	14	
r	11	15	15 died during moult.			
s	13	13	9	10	13 died in moulting.	

Another brood kept in the Laboratory gives a record of four moults in twenty-eight days. As contrasted with the two broods tabulated above, the period between the moults was much less, due no doubt to the higher temperature. Another instance is the "control brood" for Brood II, which was kept in the warm Laboratory; they were one day ahead of Brood II in the first moult and seven days ahead at the second moult.

EXPERIMENTS IN VARYING THE SALINITY.

Great variations in the salinity of the water can be endured by this species, but too sudden a change tries them severely. We have made some experiments with large adults. In one instance a male and a female were taken from the brackish water and put into fresh water on July 24th; two days later the female died, the male survived till the seventh day. Again, on July 24th, a male carrying a female was put into sea-water; they both moulted, and five days later were separate, but no eggs were produced. On August 3rd the male was again carrying the female, and on the 7th she moulted again, and again they were separate and no eggs present. On August 21st they were again paired, and on the 24th another moult was found, and the female was dead. The male died on the 26th, so he had lived thirty-three days and she thirty-one. Evidently the sexual impulse was still there, but the power to produce was affected. In a third case, two half-grown females were put straight into sea-water. One had very young eggs, which were soon thrown off; the other had two partly hatched eggs, which hatched and were extruded four days later. The two females are still alive, a month later, and their ovaries are much enlarged. The extruded young are swimming about in the sea-water.

Similar experiments just commenced with newly hatched broods promise some interesting results. They show that the first moult is critical; if that be survived they continue to flourish, but the period between moults is much longer than normal. One brood of seven *G. chevreuxi* were put into fresh water; they took from eighteen to twenty-one days to reach the first moult, and all died, either in moulting or directly after. Some nine *G. pulex* put straight into brackish water all accomplished their first moult safely, but took thirteen to fifteen days instead of seven to reach it; nine others of the same brood put into water one-third brackish to two-thirds fresh took nine days to this moult.

Finding the sudden change too drastic, a number varying in size were put on September 9th into two bell-jars. Small quantities of fresh water have been added to the one from time to time at a few days' interval, so that now the water is fresh. Although the original large adults have disappeared, we still have breeding pairs mixed with their own progeny in this jar. To the individuals in the second bell-jar small quantities of sea-water have similarly been added from time to time, and the water is now full-strength sea-water. The large adults died off in this case also, but their numerous progeny are flourishing and breeding.

The papers referred to above are:—

1. 1889. Della Valle, A. "Deposizione, fecondazione, e segmentazione delle uova del *Gammarus pulex*." Atti. Soc. Nat. Modena. Ser. III, Vol. VIII.

2. 1912. Embody, G. C. "A Preliminary Study of the Distribution, Food, and Reproductive Capacity of some Fresh-water Amphipods." Internat. Revue, Leipzig, 1912.

3. 1903. Holmes, S. J. "Sex Recognition among Amphipods." Biol. Bull., V.

4. 1912. Sexton, E. W. "Some Brackish-water Amphipoda, etc." Proc. Zool. Soc., September, 1912.

Notes on the Development of *Mytilus edulis* and *Alcyonium digitatum* in the Plymouth Laboratory.

By

Annie Matthews, M.Sc.

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1. Mytilus edulis.

No very definite statement has yet been made as to the time when *Mytilus edulis* spawns at Plymouth. However, in 1911 records of spawning in the Laboratory tanks were made in January, February, and March, and in 1912 two specimens removed from the tanks spawned in early May.

Between May 10th and 21st, 1912, 100 mussels from Plymouth Pier were kept in a Laboratory tank, but as they did not spawn they were then opened, and many found to be either spent or only partly ripe. Examination of samples brought in between May and August seemed to indicate that the spawning season was finished, and occurred therefore in the early spring.

Various attempts were made at artificial fertilization from apparently ripe members of the selected hundred, but in one case only was fertilization successful—May 21st. A piece of ripe ovary and of ripe testis were shaken about in separate finger-bowls containing "outside" water, and thus ripe eggs and spermatozoa were freed in the respective bowls. At 12 noon a few drops of water containing spermatozoa were added to the finger-bowl containing ova, and at 4 p.m. that day many of the ova were developing—some showing Polar Bodies, others the early segmentation stages. Next morning the ciliate trochospheres were swimming at the top of the water in the finger-bowl, and these were removed with a pipette to two small "Breffits"* containing outside water, to which a few drops of a Nitzschia culture were added. Development gradually proceeded, the velum at this time being of very large relative size, and as Wilson states ("5th Annual Report Fishery Board for Scotland, 1886-87"), the shell muscles and alimentary canal are now elaborated, the valves of the shell being finely pitted and almost semicircular in shape.

However, while Wilson states that his larvae (now twelve days old) never progressed beyond this stage, the specimens reared in Plymouth continued to grow and develop, and are still doing so, although very much below normal size, judging by specimens of this year's mussels brought in from outside. The valves gradually assumed a shape rather like a minute edible cockle, and about July 22nd, a purple colour—the beginning of the prismatic shell substance—appeared at the edge of the valves, behind the velum, and extending to the posterior edge of the shell. The smallest individual in which the prismatic shell substance was visible measured ·21 mm. long × ·19 mm. high. The larvae still swam with the velum and the foot was growing rapidly in size. The eye spot was present and five gill filaments, and the valves measured ·31 mm. long × ·24 mm. high. From now onward the larvae grew at varying rates, some fixing by a byssus, while many others remained unattached and much smaller, creeping about the jar. The purple colour gradually extended over the valves, fading at its edges into brown. On August 6th the foot had become very long, thin, and active, the gill cilia were long and powerful, and the velum was decreasing slowly in size. Later the foot was frequently used as a creeping organ, and on August 15th I drew one specimen that could both swim with the velum and creep with the foot; it measured ·29 mm. high × ·32 mm. long, and had six gill filaments. A similar specimen measured ·32 mm. high × ·38 mm. long, so that the young mussel ceases to swim at a much later stage than the individual Wilson saw (see Wilson, loc. cit.).

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* Wide-mouthed jars of green glass of about 2 litres capacity.

From time to time more Nitzschia was added to the jars as food, and the outside water renewed, in which they lived.

Other specimens drawn on the same day had lost the large velum and the power of swimming, and were crawling with the long tongue-like foot about the glass jars. Measured specimens were:—

·35	mm. high	× ·413	mm. long,	with 5	gill filaments.
·385	„	× ·46	„	„ 8	„
·41	„	× ·574	„	„ 10	„

In the last individual the shell resembled a minute adult shell, being much thicker and of elongated oval shape, and dark blue in colour.

On August 27th most of the young mussels were crawling about the jar, many near the water surface, the largest measuring ·74 mm. high × 1·16 mm. long, with 15–16 gill filaments. The eye spot was still visible through the shell. During September they attached themselves to the glass at various levels—some at the water surface—by a delicate byssus, all but one being fixed by October 4th. When removed forcibly they soon refixed. About October 15th the jars were aerated by a slow, fine air jet to keep the food in circulation, and this is still kept up, the mussels slowly increasing in size.

The largest individual in the jars at present measures 2·2 mm. long ×1·5 mm. high.

Note.—On August 7th, 1912, several swimming larvae, including one mussel that could both swim and crawl, were placed in a Breffit with a little of the water in which they were brought in. The jar was then filled with outside water, and the mussel, three Anomia sp. larvae, and several gastropod larvae developed and grew in this jar. No food has been added. The mussel is much larger than those wholly reared in the Laboratory, and measures 4 mm. long × 2·0 mm. high. The Anomia sp. measures 10·25 mm. across the widest diameter of the shell.

2. Alcyonium digitatum.

Male and female colonies of *Alcyonium digitatum* were placed in a tank on January 26th, 1912, and from January 27th to February 3rd, eggs in various stages of segmentation were pipetted out of the tank where they were floating, into Breffits containing Berkefeld or outside water. Hence the early critical stages of maturation and fertilization took place in the tank water. On January 28th many advanced morulæ passed into a curious irregular stage, which in turn became a round ciliate planula. This elongated gradually to an oval swimming planula, and as development proceeded the shape became pear-like, the larva swimming with the broad anterior pole forward, and simultaneously rotating on its axis. The characteristic reddish-brown colour of the egg gradually became pale cream as the larvae absorbed the yolk, and planarian-like contractile movements were observed when they were irritated by light, pipettes, etc.

Later they floated towards the base of the Breffits or near the surface film, with the long axis vertical and the anterior pole upwards, and on February 6th, some larvae had fixed on the glass at the surface film. Shrinkage now took place along the long axis, so that the oval larva became short and dome-shaped, and through the glass Breffits the eight mesenteries were visible. Some larvae settled on glass rods, glass cover-slips, and pieces of paraffin which were introduced into the Breffits at this time. By invagination of the ectoderm at the free pole of the larva, the mouth and stomodeum now arose,—fifth day of fixation, and as the yolk was absorbed it became paler and more transparent. Later eight simple tentacles appeared round the mouth, so that the larva now resembled a small anemone. By February 17th the tentacles were well developed and bore 2–3 lateral branches, and they waved gracefully about in the water if undisturbed, but retracted completely if shaken or disturbed. Forty days later the solitary polyp had grown very considerably, but no lateral buds had arisen. The base of the polyp now was approximately 1 mm. in diameter. The only food added to the water was a little Nitzschia from time to time, but they were never seen taking it in.

They lived healthily until April 3rd,—two months approximately, but were then preserved, as flagellates had attacked them.

This work is being continued and amplified, and it is hoped that a complete account of the development of *A. digitatum* will soon be forthcoming.

Notes on the Structure and Mode of Action of the "Oval" in the Pollack (*Gadus pollachius*) and Mullet (*Mugil chelo*).

By

W. N. F. Woodland, D.Sc.,

Professor of Biology in the Muir Central College, Allahabad, India.

With Seven Figures in the Text.

DURING the summer of 1911 I conducted at the Plymouth Biological Station a series of experiments on the living active gas-gland associated with the bladder of certain marine fish, the results of which are recorded in a paper published in the *Anatomischer Anzeiger* for 1911 (Bd. XL, p. 225). Whilst so employed I incidentally made some observations on the structure and mode of action of the "oval" in fishes, and since my conclusions differ in several particulars from those of Nusbaum and Reis (*Bull. Acad. d. Sciences Cracovie*, 1905, p. 778; *Anatomischer Anzeiger*, Bd. XXXI, 1907, p. 169), I think it as well to put them on record. Most of my observations were made on the Pollack. If a weight be attached to this fish so as to cause the gas-gland (oxygen gland) to become active and to pump oxygen into the bladder, it will be found that the oval strongly contracts, so as to prevent the additional gas forced into the bladder from escaping into the blood. The oval, it may be mentioned, is a large oval area usually situated in the dorsal posterior wall of the bladder. It differs from the rest of the bladder wall in that it alone is permeable to the contained gases, and, like the ductus pneumaticus in Physostomi, permits their escape when the conditions require it. In the Pollack the oval is normally widely open and is invisible to the naked eye, but on the gas-gland being caused to become active in an unusual degree, the oval becomes strongly contracted and is then a very conspicuous structure inside the bladder. This contraction of the oval is of course effected by muscles, and the result of it is to cause the thin-walled permeable area to become more or less completely shut off from the general bladder cavity, the walls of which, as just mentioned, are impermeable.

According to the observations of Nusbaum and Reis on the ovals of Perca, Lucioperca, and Ophidium, the oval has the following structure:—The ordinary wall of the bladder is composed of three layers: an inner elastic and muscular layer covered internally by the squamous epithelium lining the bladder cavity, a middle conjunctive and vascular layer, and an outer fibrous layer. At the periphery or edge of the oval there is developed a special band of circular smooth muscle fibres, which by contraction can lessen and obliterate altogether the area of the oval exposed to the gases in the general bladder cavity. Over this area, limited externally by the circular band just mentioned, the inner layer is quite absent, only the squamous epithelium being present, and this latter in consequence abuts directly on the middle layer, in which, in the oval area, the capillary system is much developed.* In the region of the oval, therefore, the gases contained in the bladder can come into very close contact (only separated by the squamous epithelium) with the numerous capillaries of the oval contained in the middle layer. Attached to the edge of the oval, immediately external to the circular muscle band, are numerous radial muscle fibres (belonging to the inner layer surrounding the oval), the function of which is to act in opposition to the circular band and enlarge the oval area. The foregoing statements and the mode of action of the oval, according to Reis and Nusbaum, are illustrated by Figures 1–4 (devised from the statements and diagrams of these authors). It will be seen that, according to these authors, the closure of the oval, in the fishes studied by them, is effected by the simple contraction of the circular muscle band (the radial muscles slackening), the squamous epithelium being thereby raised from contact with the blood-vessels and separated from them by the muscles. I presume that these statements of Nusbaum and Reis are based upon the study of actual sections of closed and open ovals; otherwise I should doubt their accuracy, because this mode of action of the oval is quite unlike that of the oval in the Pollack and the Mullet, because I find it difficult to believe that the squamous epithelium ever becomes separated from the capillary plexus in the manner asserted, and finally because, if Tracy (*Anat. Anzeiger*, 1911) is correct in his interesting view that the oval is homologous with the posterior chamber of the Carp bladder and the distal part of the ductus pneumaticus of Physostomi (Fig. 7), these statements are improbable *a priori*. It is evident that if the edge of the oval is homologous with the circular edge of the septum separating the anterior and posterior chambers of the Carp or Siphonostoma bladder, then it might naturally be anticipated that the

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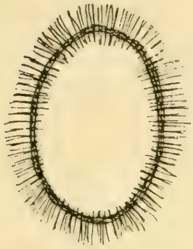
* The so-called "wundernetz"—a bad term, since this special capillary development has nothing to do with the rete mirabile duplex situated on the artery and vein supplying the gas-gland (*vide* my *Anat. Anzeiger* paper already mentioned and *Proc. Zool. Soc., Lond.*, 1911, p. 183).



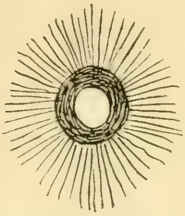


Fig. 1 Open Oval (Surface View). Fig. 2. Semi-closed Oval.

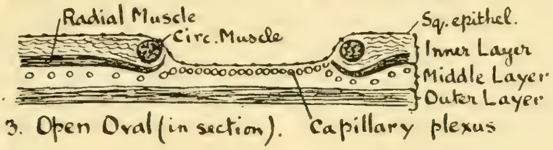

Radial Muscle
Circ. Muscle
Sq. epithel.
Inner Layer
Middle Layer
Outer Layer
Capillary plexus

Fig. 3. Open Oval (in section).

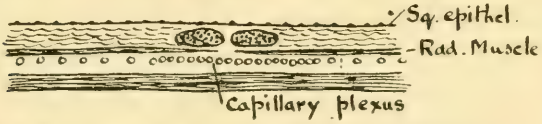

Sq. epithel.
Rad. Muscle
Capillary plexus

Fig. 4. Closed Oval (in section). The squamous epithelium is separated from the capillaries.

Diagrams adapted from the description & diagrams of Nusbaum & Reis.

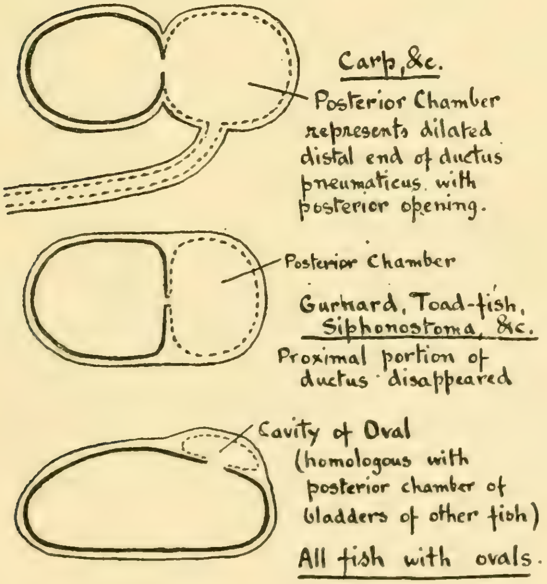

Carp, &c.
Posterior Chamber represents dilated distal end of ductus pneumaticus, with posterior opening.
Posterior Chamber
Gurnard, Toad-fish, Siphonostoma, &c.
Proximal portion of ductus disappeared
Cavity of Oval (homologous with posterior chamber of bladders of other fish)
All fish with ovals.

Fig. 5. Derivation of Oval, according to Tracy.

oval area would be shut off from the general bladder cavity in the same way that the cavity of the posterior chamber is shut off from the anterior in the Carp bladder. My investigations prove that this last anticipation is correct in the case of the ovals of the two fish (Pollack and Mullet) which I have examined. As shown by Figs. 5 and 6, the oval in the Pollack opens and closes by means of a circular fold which works like the shutter of an iris diaphragm. The impermeable inner layer of the bladder wall is shown by a thick line, and, as the figures indicate, this ceases at the edge of the open oval, the oval area merely being covered by the thin layer of squamous epithelium. As the figures also indicate, the circular fold is formed by the actual rotation of the tissue round the edge, hence the more closely shut the oval the deeper is its cavity. This deep cavity of the closed or nearly closed oval is very obvious in the actual bladders of the Pollack, Mullet, and other fish, but, according to the statements of Nusbaum and Reis, it does not exist in the species they examined. I am, of course, quite ready to admit that all ovals may not work on the same principle—in *Dactylopterus volitans*, e.g., I find that the oval-like structure has in section an appearance different in several particulars from that of the normal oval; at the same time, I shall feel more satisfied that the mode of action of the oval in Perca, Lucioperca, and Ophidium is different from that of the oval of Gadus, Mugil, and other fish, if Nusbaum and Reis would supply us with figures constructed from observations of actual sections of the open and closed oval instead of mere diagrams which, to say the least, look very hypothetical. The figure of the open oval of Lucioperca published by Reis (Kraków, *Rozpr. Akad.*, 1906, pp. 639–670) is of little use as evidence in the present connection.

I must point out, in conclusion, that, literature being not easily accessible in the centre of India, papers bearing upon the above subject may have been published without my knowledge since I left University College, London. I must also confess that I am unacquainted with the exact nature of the controversy concerning the oval between Nusbaum and Jaeger. Possibly Jaeger has already stated the objections I have urged above. If so, he has not confirmed them with figures. Finally, I may mention that I have exhibited my own sections of the open and closed oval at the Royal Institution of London, where they were examined by several zoologists of repute.

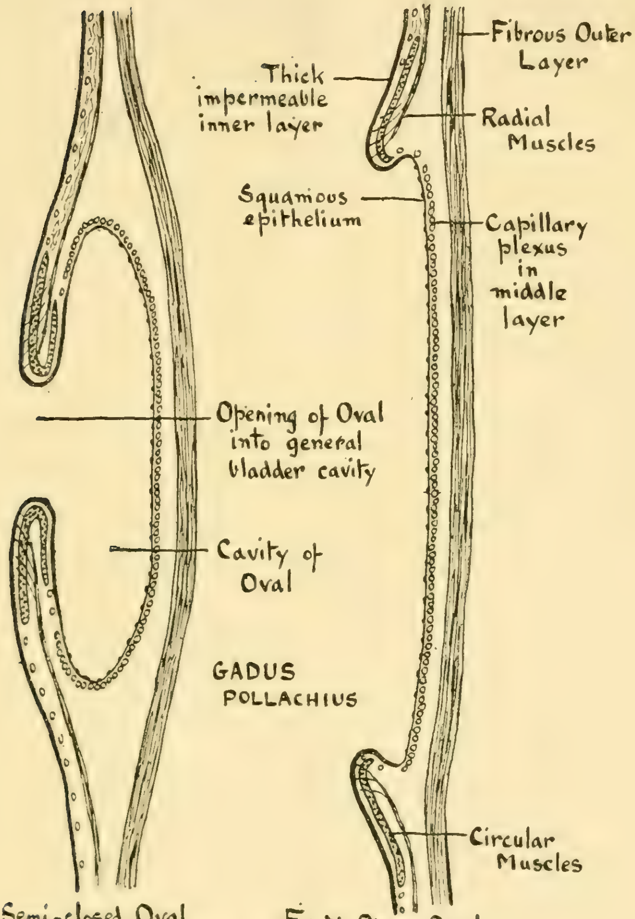

Thick impermeable inner layer
Fibrous Outer Layer
Radial Muscles
Squamous epithelium
Capillary plexus in middle layer
Opening of Oval into general bladder cavity
Cavity of Oval
GADUS POLLACHIUS
Circular Muscles

Fig. 6. Semi-closed Oval. Fig. 7. Open Oval.
Diagrammatic figures constructed from sections.

An Experimental Investigation on the Function of Reissner's Fibre.

By

George E. Nicholls, B.Sc., A.R.C.Sc., F.L.S.,
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Some fifty years ago a German investigator, Reissner, discovered *lying freely in the central canal of the spinal cord* of the lamprey a very fine cylindrical rod, which he supposed, notwithstanding its unusual situation, to be a delicate nerve fibre. He failed, however, to learn anything concerning its connection with the central nervous system, and his discovery, although confirmed, seems to have attracted but little attention. The few observers who have since that time recorded observations upon Reissner's fibre were almost all agreed that it was to be looked upon merely as an artifact produced by the coagulation of the cerebro-spinal fluid by the action of the fixing reagents employed.

In the early years of the present century, however, Sargent (1900–1904) took up the study of this fibre of Reissner and announced that he found it to be a *nerve tract* which formed a direct connection between the optic centre in the mid-brain and the musculature, and permitted, he believed, of a quicker response to optic stimuli than was possible through the ordinary spinal tracts. He claimed to have obtained experimental confirmation for this theory, by observations made upon elasmobranchs, in which he had broken the continuity of the fibre, declaring that he could detect an appreciable slowing in the passage of optical stimuli in the subjects of his experiments as exhibited by their failure to quickly avoid obstacles placed unexpectedly in their path.

My own observations upon Reissner's fibre and related structures in the central nervous system, which were begun in 1907 and have continued until the present time, while establishing beyond question the fact that the fibre is really a preformed structure,* have at the same time shown conclusively that it is not a nerve fibre or a nerve tract.

I have been able to demonstrate that the fibre takes its origin from an extraordinary epithelial organ which lies beneath the posterior commissure. This structure, for which the name sub-commissural organ has been proposed (and which, as I shall hope to show in a paper now nearly ready for publication, develops from an anlage in the brain, which is serially homologous with the anlage of the lateral and pineal eyes), *must be looked upon as an intra-cerebral sense organ.* In early development a paired structure, it takes up, in many forms, a median dorsal position, and in almost all vertebrates becomes in the adult a most conspicuous structure in the mid-brain.

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* Edinger, as recently as 1908, had affirmed that it was merely an artifact.

It is from the internal (ventricular) aspect of the cells of this organ that Reissner's fibre arises as a large number of cilia-like fibrillae, which converge beneath and behind the posterior commissure into a rod-like structure which may, at its anterior end, be either paired at first or single and median. In either case it shortly becomes a single median thread and stretches backward as such to the extreme hind end of the central nervous system. Beneath the rhombo-mesencephalic fold it frequently comes to lie in a well-marked dorsal median groove (the "isthmic canal"), which deepens with age, and which may be paired if the paired character of the fibre is maintained so far caudally.

Through the central canal of the spinal cord Reissner's fibre may be traced backwards lying centrally and apparently supported at frequent intervals by cilia from the ependymal cells.

At the actual extremity of the spinal cord (filum terminale) the central canal widens out into a sub-spherical space which was named by Retzius* the sinus (ventriculus) terminalis. This chamber is not, however, wholly enclosed within the nervous system, for, posteriorly, the ependymal epithelium—which alone constitutes this part of the filum terminale—fails entirely, and there is left a wide opening which I have called the "terminal neural pore." The wall of the sinus terminalis is thus completed posteriorly only by the connective tissue sheath of the spinal cord. Into this meningeal wall Reissner's fibre, flaring out into a trumpet-like end, passes and is inserted.

If in freshly killed material Reissner's fibre be cut, it recoils spirally in both directions from the point of section, forming dense tangled knots such as would be formed in a thin elastic thread which, held firmly at one end, *was twisted from the free end continually in one direction.* In this reaction, as also in its straining reactions, in its origin in the brain, and in its ending in the meninges, Reissner's fibre is altogether unlike any known nerve.

Since then it is not a nerve, Sargent's "Optic Reflex Theory" can no longer be maintained, and the question of its function (and that of the related sub-commissural organ) is reopened.

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* Retzius knew of its occurrence only in Amphioxus and Cyclostomes. It is to be found even better developed in Elasmobranchs and Teleosts.

The supposed inaccessibility of the fibre had led Sargent to operate upon it in the region of the hind-brain, and his experiments were therefore open to the serious objection that they involved great risk of grave damage to the brain itself. My discovery, however, that the fibre is, in the lower vertebrates at any rate, comparatively readily accessible in the region of the tail (where it actually passes out of the central canal of the sheltering spinal cord through the terminal pore), suggested the practicability of experimental work upon Reissner's fibre without danger of damage to the central nervous system.

The experiments, which consisted simply in breaking the fibre by a slight incision at the end of the filum terminale, were carried out in the Laboratory of the Marine Biological Station at Plymouth, in the summers of 1910 and 1911, and I desire here to acknowledge my obligations to the British Association for the Advancement of Science, and the Senate of London University for the use of their Tables, and also to the Royal Society for a Grant which enabled me to carry out the more extensive series of experiments in 1911. My thanks are also due to Dr. Allen and the other members of the staff for the courteous way in which they met my wishes and facilitated the carrying out of the work.

In all, the experiment was carried out upon some seventy specimens (dogfish and rays), and a short account of the earlier experiments has already been published (*Anat. Anz.*, Bd. XL, pp. 409–432). In compliance with the conditions under which the licence to conduct the experiments was granted the specimens were anæsthetized—a most unnecessary precaution (in view of the trivial character of the operation, which rarely drew a drop of blood), and one which, in the case of some of the subjects of experiment, proved a much more serious matter than the operation itself.

Upon these anæsthetized specimens the necessary prick was quickly inflicted and the specimens returned to the tank. Subsequent observation (extending in different cases over a period of less than an hour to as much as three weeks or more) showed that apart from a slightly different action in swimming, which I found almost impossible to analyse and describe, the only discoverable effect of the operation was that many of the specimens when at rest adopted a pose which was markedly unlike that of the normal animal. In the normal specimen at rest the under surface of the head and the lower lobe of the caudal fin touch lightly upon the supporting surface, and the entire long axis of the body extends in a straight line. In these subjects of the experiments (in which subsequent microscopic examination of the material showed that the fibre had been broken) the animal was found to retire to the darkest part of the tank and there to remain sluggishly with head and tail sharply uplifted, and often with the body sharply bent or in a sinuous curve. In the rays, the whole body was often strongly arched transversely as well. The reaction lasted for a longer or shorter period, and was usually very pronounced.

Subsequently, in the aquarium, specimens were found showing this reaction, and the examination by sections of their central nervous system showed that in each case Reissner's fibre had been broken in life, presumably by some recent accident.

Thus the principal result of the breaking of Reissner's fibre in the living animal appears to be that the animal adopts, while at rest, an unnatural pose, and probably also swims with a slightly different action. This lends support to the suggestion put forward by Dendy (*Nature*, December, 1909), that the apparatus forms part of a mechanism for automatically regulating flexure of the body.

A List of Blood Parasites of Sea Fish taken at Plymouth.

By

Herbert Henry, M.D.

The following is the result of an investigation with regard to the occurrence of haemoprotozoa in sea fish taken in the neighbourhood of Plymouth :—

A. *In May*, 1911.

	Number examined.	Number with haemogregarines.	Number with trypanosomes.	Number with new parasites.
Solea vulgaris . .	4	4(1)	—	—
Callionymus lyra . .	15	5(2)	1(3)	—
Cottus bubalis . .	10	2(4)	—	—
Blennius pholis . .	6	6(5)	—	—
,, gattorugine .	1	—	—	—
Gobius paganellus . .	9	2(6)	—	—
Agonus cataphractus .	5	1(7)	1(8)	—

B. *In August–September*, 1912.

Pleuronectes platessa .	13	2(9)	—	—
Callionymus lyra . .	4	—	—	—
Blennius pholis . .	2	2(5)	—	—
,, gattorugine .	2	2(5)	—	—
Gobius ruthensparri .	5	—	—	—
,, minutus . .	4	—	—	—
,, paganellus . .	31	3(6)	—	—
Motella mustela . .	9	—	—	1(10)
Cottus bubalis . .	13	2(4)	—	—
Rhina squatina . .	5	—	—	—
Solea lutea . . .	6	1(11)	—	—
,, vulgaris . .	13	12(1)	—	—
Gasterosteus spinachia .	8	—	—	—
Scomber scomber . .	36	—	—	2(12
Agonus cataphractus .	1	—	—	—
Siphonostoma typhle . Syngnathus acus . .	12	—	—	—

LIST OF PARASITES WITH REFERENCES.

(The numbers are the index figures in the above table.)

1. Haemogregarina simondi . . . . Laveran et Mesnil, "Deux Hémogrégarines nouvelles des Poissons," Compt. rend. Acad. d. Sc., Paris, 1901, tome cxxxiii., p. 572.
2. Haemogregarina quadrigemina . . Brumpt et Lebailly (see ref. 3).
3. Trypanosoma callionymi . . . . Brumpt et Lebailly, "Description de quelques nouvelles espèces de Trypanosomes et d'Hémogrégarines de Téléostéens marins," Compt. rend. Acad. d. Sc., Paris, 1904, tome cxxxix., p. 613.
4. Haemogregarina cotti . . . . . . Brumpt et Lebailly (see ref. 3).
5. Haemogregarina bigemina . . . . Laveran et Mesnil, 1901 (see ref. 1).
6. Haemogregarina polypartita . . . Neumann, "Studien über protozoische Parasiten im Blut von Meeresfischen," Ztschr. f. Hyg. u. Infectionskrankheiten, Leipzig, 1909, Bd. xiv., Heft 1, S. 1.
7. A Haemogregarine (to be described).
8. A Trypanosome (to be described).
9. Haemogregarina platessae . . . . Lebailly, "Sur quelques Hémoflagellés des Téléostéens marins," Compt. rend. Acad. d. Sc., Paris, 1904, tome cxxxix., p. 576.
10. A new parasite (to be described).
11. Haemogregarina clavata . . . . . Neumann (see ref. 6).
12. A new parasite (to be described).

All fish were carefully examined for ecto-parasites, as possible carriers of infection, with the following results:—

1. On two specimens of Solea vulgaris, there was found a leech Trachelobdella lubrica? (HARDING: "A Revision of British Leeches," Parasitology, Cambridge, vol. iii., No. 2, pp. 136–9).
2. On five specimens of Solea vulgaris, there was found a trematode, Phyllonella soleae (BRONN: Das Thierreich, Leipzig, 1879–93. Abth. I A, Bd. iv., S. 363, S. 527).
3. On two specimens of Scomber scomber, a parasitic copepod, Caligus scombri (BASSET, SMITH: Ann. and Mag. Nat. Hist., 1898, vol. ii., p. 83, pl. 14, fig. 2. THOMAS SCOTT: "Notes on some Parasites of Fishes," Nineteenth Annual Report of Fishery Board of Scotland, 1901).

ABSTRACTS OF MEMOIRS

RECORDING WORK DONE AT THE PLYMOUTH LABORATORY.

Experimental Metaplasia. I. The formation of columnar ciliated epithelium from fibroblasts in Pecten. By G. Harold Drew.

(*Journal of Experimental Zoology*, Vol. X, 1911, pp. 349-379.)

THE implantation of small pieces of the ripe ovary of *Pecten maximus* or *Pecten opercularis* into the adductor muscle of another animal of the same species was found to result at first in the formation of a closed cyst within the muscle, lined with layers of fibroblasts. Complete degeneration and disintegration of the ovarian tissue within the cyst occurred in a few days, and then the cyst contained only an orange-coloured granular substance, presumably derived from the yolk, and numbers of blood corpuscles. After the lapse of from twenty-one to thirty-two days, changes occurred in the innermost layer of fibroblasts lining the cyst. They reverted to an embryonic type, and afterwards became converted into columnar ciliated epithelium, which formed a continuous layer lining the cyst. The changes resulting in this formation of ciliated epithelium from fibroblasts were followed clearly step by step, and once formed, the ciliated cells persisted unaltered for at least 120 days, which was the longest period for which the animals could be kept alive under experimental conditions.

Experiments were performed showing that this change is not produced by the implantation of any of the other tissues of Pecten, by neutral foreign bodies which would merely act as a source of mechanical irritation, by the transplantation of the ripe ovarian tissue of other Lamellibranchs, or by the transplantation of pieces of the ovary of *Pecten opercularis* into the adductor muscle of *Pecten maximus*, and vice versa.

Other experiments showed that the development of ciliated epithelium does not occur if pieces of the immature or spent ovary be implanted, and that it is prevented by treating the ripe ovary with a suspension of the sperm in sterile sea-water before implantation. Also that it does not occur if the ovary be killed by physical or chemical agents before implantation. A series of experiments were made to eliminate the possibility of the origin of the ciliated epithelium lining the cysts from the ciliated cells of the oviduct, which might be present in pieces of the ovary that were implanted, or from the layer of epithelial cells forming the outer coating of the adductor muscle, which might be carried inwards by the transplanting needle.

It thus appears that the conversion of fibroblasts into ciliated epithelium is a specific reaction following the implantation of the ripe living ovary.

These observations were the result of nearly a thousand experiments, of which the majority were performed on *Pecten opercularis.*

It appears that this conversion into ciliated epithelium of the inner layer of fibroblasts lining a cyst formed round a piece of the ovary, which has been implanted into the adductor muscle of Pecten, is a specific reaction that occurs only when the ripe living ovary of an animal of the same species is implanted. The reaction takes place long after all trace of organized structure in the implanted tissue has disappeared, and it is difficult to conceive of its being due to any other cause than the presence of some definite chemical substance within the cyst, which is characteristic of, and specific for, each species.

Examination of the contents of the cysts showed, in all cases where the development of ciliated epithelium had occurred, that an orange granular substance, and blood corpuscles in various stages of degeneration, were present. These orange granules resembled in appearance the orange-coloured yolk substance of the ripe ova, and the amount of this granular substance within the cysts seemed to be independent of the length of time during which the implanted tissue was allowed to remain in the muscle. If implantation of pieces of the ovary of approximately equal size were made, examination of the contents of a cyst after six days showed as much of this substance present as in a similar cyst after 120 days; hence it appears that this substance cannot escape through the cyst wall. When it is considered that the development of the ciliated epithelial lining only occurs as a reaction to the implantation of ripe ova, containing a plentiful supply of the orange-coloured yolk substance, there is at least a possibility that the orange substance within the cysts bears a close chemical relation to the yolk substance, and that the development of ciliated epithelium from the fibroblasts lining the cyst is a specific reaction to its presence.

Though admittedly based on no experimental evidence, it is suggested as a possible explanation of the phenomena that some substance is formed as a result of the ingestion of these orange granules by the blood corpuscles, and their subsequent degeneration within the cyst: that the granules themselves remain unchanged, and are again set free on the disintegration of the corpuscles, and that their action on the protoplasm of the corpuscles is merely catalytic. This substance, produced from the blood corpuscles, is probably a fluid, and would be slowly and continuously formed as long as blood corpuscles could pass through the walls of the cyst. The action of this substance on the fibroblasts forming the walls of the cyst is to delay their return to the spindle shape typical of the resting condition, and eventually to set up those changes in the inner layer of fibroblasts resulting in their conversion into ciliated epithelium.

G. H. D.

A Review of the British Marine Cercariae. By Marie V. Lebour, M.Sc. (*Parasitology*, Vol. IV, No. iv, January, 1912.)

THE work in this paper on *Spelotrema excellens* Nicoll was partly carried out at Plymouth in April, 1911. The first host of this worm seems most commonly to be *Littorina obtusata ; L. rudis* and *Paludestrina stagnalis* are also first hosts for it. The tailed cercaria occurs in sporocysts in the digestive gland of these molluscs, and possesses a stylet in its head by which presumably it bores its way into its second host, the green crab, *Carcinus maenas.* Here it encysts and gradually enlarges, loses its stylet, and assumes the *Spelotrema* form, the walls of the cyst thickening until a certain size is reached, when the cercaria rests. The full-grown cysts are found all the year round, but no young stages in the winter. All the Plymouth crabs seem to be infected and in almost every organ, the digestive gland and muscles being the favourite parts. The final host of the worm is probably the herring gull, *Larus argentatus.*

M. V. L.

Contributions to the Knowledge of the Laminarias. (*Beiträge zur Kenntnis der Laminarien.*) By C. Killian. (*Zeitschrift für Botanik*, 1911, Heft 7.)

NOTWITHSTANDING the large number of papers on Laminaria, its development was until recently but little understood, for it was only in 1910 that Drew published an account of the first successful cultures. Thanks to the previous work of that author, the writer succeeded in getting the swarm spores of *Laminaria digitata* to germinate. First of all there developed a germinal thread consisting of a few cells; from certain of these cells secondary, one-layered laminae sprouted, which were joined to the germinal thread by colourless rootlet cells. Later these rootlet cells disappeared, and then the laminae, freed from the germinal threads, developed on their lower sides rhizoids which established a direct attachment to the rocks. In the young plants the cell divisions proceed at first regularly over the whole surface. It is only later that the intercalary growing point is formed between the rhizoids and the leaf; in addition growth tissue develops at the edge of the leaf and makes the extension of the surface in breadth possible. Gradually the young plant becomes many-layered; the outer layers consist of isodiametric, the innermost of elongated cells with rich intercellular substance; only the point remains for the time one-layered. It must, however, be noted that in the stalk the rows of newly formed central tissue remain near together; in the leaves, on the other hand, where the growth in breadth strongly predominates, the original longitudinal rows become more and more pulled asunder. A further complication is added, in that (1) between these rows of the internal tissue connections already existed which are now simply mechanically pulled apart, and (2) new connections of this kind are formed. These new connections occur through two cells, which develop at opposite points on the longitudinal rows, growing towards one another and becoming fused. From a cell resulting from such fusion a chain of cells then forms by transverse division. In still later stages the single cells of the longitudinal and transverse rows of the central tissue, whose power of growth ceases, become mechanically deformed through the rapid growth of the leaf. In this way there finally result tube-shaped cells which, according to their age and the degree of the tension to which they are subjected, differ from one another in appearance. We can thus understand the confused mass of cells of all possible shapes which is presented by a section through the central tissue of an old plant. Similar pictures such as one finds in other Laminarias suggest that in them also tissue development takes the same course.

A point in the anatomy of the haptera is worth noting, viz., that in these there are internally no elongated, tube-shaped cells. As is well known, these algae possess at first an adhesive disc from which the organs of attachment take origin, the construction and shape of the latter being modified by external conditions.

It is well known that the different representatives of the Laminariae are characterized by regularly split leaves. In order to understand the processes which bring about the formation and the repair of these slits, experiments were undertaken by the author with a view to explaining the reactions and tissue-formations which follow as the result of wounding. It was shown that *Laminaria digitata* after being wounded reacted rapidly and vigorously. The differentiation in the stem, leaf, and haptera, the age and the corresponding specialization of the tissue cause manifold differences in the regeneration, and the direction and character of the wound also exert an influence. As regards the tearing process, which may be especially well seen in *Laminaria hyperborea*, it appeared that these plants slit their leaves autonomously. This is made clear by a microscopical investigation of the leaf surface in the neighbourhood of such a tear. The epidermis at such a place bends inwards from both leaf faces more and more into the inner tissue. One cannot, be it noted, speak of any external wounding. When the epidermis has forced itself in this way into the central tissue the latter finally becomes torn and the further growth of the epidermis closes the wound. From this normal slit-formation and healing we must distinguish the purely mechanical splitting, which heals in exactly the same way as the wounds in the experiments already mentioned. In nature both kinds of slit-formation run into one another. In other Laminarias a similar state of things seems to exist.

Field observations show that Laminarias have definite requirements as to light, heat, salinity, change of water, etc., at each different age. Differences in the external form of the different parts of the thallus clearly depend upon changes in these conditions. Laboratory experiments showed that Laminarias from different localities in the neighbourhood of Plymouth possessed different degrees of elasticity, and algae from places where wave movement was slight were stretched, with one and the same load per unit area of section, to a greater extent than the more resistant individuals from very exposed localities. Plants which grew under similar conditions showed, on the contrary, an equal degree of extension. *Laminaria digitata* stretched similarly to *L. saccharina*, whilst the surf-loving species *L. hyperborea* and *bulbosa* were more resistant.

K.

Notes on the Choanoflagellate Genera *Salpingoeca* and *Polyoeca*, with Description of *Polyoeca dumosa*, sp. n. By J. S. Dunkerly, B.Sc. (*Annals Mag. Nat. Hist.*, Ser. 8, Vol. V, Feb, 1910, pp. 186–191.)

Note on our Present Knowledge of the Choanoflagellata. By J. S. Dunkerly, B.Sc. (*Journ. Quekett Micr. Club*, April, 1910, pp. 19–24.)

THE following is a summary of observations on some Flagellata at Plymouth Marine Biological Station during the month of August, 1909.

Certain late division stages of *Salpingoeca vaginicola* and the setting free of the daughter cell were observed, and a new species of *Polyoeca*, *P. dumosa*, was described from material taken from a tank in the Laboratory, the type species, *P. dichotoma* S. K. not having been recorded since 1874. The above results were described with figures in *Ann. and Mag. Nat. Hist.*, Ser. 8, Vol. V, 1910, and in addition to the above, the following species of Choanoflagellidae were found:—

Codonosiga botrytis J. Cl.
Codonocladium umbellatum Tat.
Salpingoeca vaginicola St.
" *ampulla* S. K.
" *urceolata* S. K.
" *napiformis* S. K.
Polyoeca dumosa n. sp.

Although careful search was made, none of the double-collared forms, *Diplosiga* Frenz. or *Diplosigopsis* Francé, were found, and I have been unable to find these in material from many different localities. That another interpretation than that of a double collar may be placed upon some of the published figures of these forms I have pointed out in another place (*Journn. Quekett Microsc. Club*, Ser. 2, Vol. XI, 1910).

J. S. D.

Marine Biological Association of the United Kingdom.

Report of the Council, 1911–12.

The Council and Officers.

Four meetings of the Council have been held during the year, at which the average attendance has been 13. The meetings have been held in the rooms of the Royal Society and of the Linnean Society, and the thanks of the Association are due to the Councils of these two Societies for allowing their rooms to be used. A Committee of the Council visited the Plymouth Laboratory on June 1st, and inspected both the buildings and boats belonging to the Association.

The Plymouth Laboratory.

Some expense has been incurred this year in re-pointing the upper parts of the south front of the building. This was rendered necessary owing to the exposed position of the building and the exceptionally wet and stormy weather of the past winter, in consequence of which the walls became damp and the ends of the roof joists were threatened. It is hoped that the work now done will prevent a repetition of the trouble. In other respects the buildings are in good condition, and the engines and pumps are in good working order. The Aquarium has been repainted and redecorated throughout, and the general equipment of the Laboratory has been maintained in an efficient state.

It was again necessary to hire a room at the Yacht Club during the Easter vacation in order to accommodate the students attending classes at the Laboratory.

The Boats.

The *Oithona* was refitted during the winter, and has been running again since the beginning of March.

Col. G. M. Giles was kind enough to present to the Laboratory a twenty-five-foot motor-boat, which is proving very useful for work in Plymouth Sound. The late Mr. W. I. Beaumont—whose recent death by accidental drowning whilst yachting in Loch Fyne is a cause of deep regret to the many friends who have met him at the Laboratory, which he has constantly visited during the last seventeen years—also presented the Laboratory with a small punt, which is very convenient for use with the motor-boat.

A floating cage or tank has been constructed and moored in Cawsand Bay. This has proved very useful for storing animals of various kinds before bringing them to the Laboratory. It has been found that animals, especially those captured in deeper water, live much better in the Laboratory tanks after having spent some time in this floating tank.

The Staff.

In addition to the members of the staff mentioned in last year's Report, Mr. L. R. Crawshay has been employed temporarily to complete his report on the fauna of the deep-water grounds of the English Channel which lie to the south-west of the Eddystone.

Occupation of Tables.

The following Naturalists have occupied tables at the Plymouth Laboratory during the year:—

K. H. BARNARD, B.A., Cambridge (General Zoology).
Prof. CHAS. CHILTON, D.SC., New Zealand (Amphipoda).
W. DE MORGAN, Plymouth (Experimental Zoology).
Miss D. DALE, Cambridge (assisting Mr. G. R. Mines).
Prof. A. DENDY, F.R.S., London (Sycon).
G. H. DREW, B.A., Plymouth (Tissue Transplantation).
Miss K. DUFFY, Manchester (Cycloporus).
Señor FERRER, Madrid (General Zoology).
H. M. FUCHS, Cambridge (Hybridization of Echinus).
E. S. GOODRICH, F.R.S., Oxford (Polychaeta).
J. GRAY, Cambridge (Experimental Zoology).
Dr. M. HASPAR, Marburg (Polyzoa).
H. LYSTER JAMESON, D.SC., London (Mussels).
K. R. LEWIN, B.A., Cambridge (Protozoa).
Miss JORDAN LLOYD, Cambridge (Experimental Zoology).
Mrs. MATTHEWS, Plymouth (Development of Alcyonium).
G. R. MINES, M.A., Cambridge (Physiology of Heart Muscles).
G. E. NICHOLLS, B.SC., London (Nervous System of Fishes).
C. SHEARER, M.A., Cambridge (Experimental Zoology and Dinophilus).
GEOFFREY SMITH, M.A., Oxford (Blood of Carcinus).
Prof. J. STEPHENSON, D.SC., Lahore (Polychaeta).
J. TAIT, D.SC., Edinburgh (Blood of Crustacea).
Miss A. W. THOMSON, Oxford (Fish Parasites).

The usual Easter Vacation Course in Marine Biology was this year conducted by Mr. L. R. Crawshay, and was attended by thirteen students from Oxford and Cambridge. Dr. Cresswell Shearer again brought a class of five students from Cambridge for a practical course in Experimental Embryology.

Mr. E. J. Lewis brought a class of seven boys from Oundle School for practical work during the last fortnight of April, and Messrs. J. T. Cunningham and H. B. Lacey, with four students from the South-Western Polytechnic, Chelsea, spent Whitsuntide in working at the Laboratory.

General Work at the Plymouth Laboratory.

The Director has continued his experimental investigations into the conditions of growth of marine plankton diatoms. Several of the latter can now be cultivated in almost entirely artificial solutions prepared from the purest chemical salts obtainable, and in this way an opportunity is afforded for studying directly the effect of minute changes in the composition of the medium in which these diatoms live. It is hoped that these experiments will eventually throw considerable light upon the causes which bring about the variations in the quantity of minute vegetable life which take place in the sea itself. Since it is this minute vegetable life which forms the fundamental food-supply of all marine animals, an exact knowledge of the conditions under which it can best flourish is of importance from both a theoretical and a practical point of view.

Mr. D. J. Matthews has been carrying out investigations on the chemistry of sea-water. These investigations have been directed chiefly to those points in which the Laboratory tank-water differs from the normal sea-water of the district. Determinations of the hydrogen-ion concentration by Sörensen's colorimetric method showed that the tank-water was decidedly less alkaline than the outside water, the alkalinity measured by this process being the true alkalinity as opposed to the titration alkalinity, which only measures the quantity of base combined with acids volatile when boiled with a dilute mineral acid. Analysis has shown that this deficient alkalinity is due not only to an excess of carbonic acid, but also to a far greater excess of nitrates and phosphates. A quantity of carbonate of soda added gradually to the water caused a considerable temporary improvement, and plutei were reared nearly to metamorphosis under the circulation. The method has been discontinued on the large scale on account of the continual rise in the relative amount of sodium salts which it causes, but small-scale experiments in which it is possible to measure the changes more accurately and to keep a complete record of the results are being carried out. As the nitrates, and also the large excess of ammonia are almost certainly of bacterial origin, some experiments have been made on treatment with a solution of bleaching powder. This reduced the ammonia to one-third and killed all the bacteria, but the method was abandoned as it caused temporary discomfort to the anemones and other invertebrates in the tank. Treatment by electrolysis is now being tried and has given encouraging results. The ammonia is reduced and all the bacteria killed without affecting any other living organisms present, whether fish or invertebrates, and samples of the water removed in flasks while still smelling of hypochlorous acid gave rise to an abundant growth of diatoms and green algae. There is a possible commercial application of this process to the treatment of shell-fish from sources open to contamination, and experiments on these lines are being carried out.

The dissolved oxygen has been determined from time to time, and the water has been always found saturated with this gas, even when the tank was cut off from the general circulation and run on aeration alone.

At Christmas there is always considerable difficulty in obtaining food for the fish, and advantage was taken of this period of enforced starvation to determine the rate of increase of the bacteria. A small tank containing a rather large number of pollack was cut off from the circulation and run on aeration alone. After three days, during which the fish had no food, the number of bacteria was only 3200 per cubic centimetre; five hours after feeding the number had risen to 46,000, and next day, after a second lot of food had been given, there were over 150,000 per cubic centimetre. This last number is probably much higher than the average for the whole system.

Colorimetric examination of the outside water has shown that the alkalinity during the early part of the spring of the present year (1912) was far less than during the previous late summer and autumn.

Mr. F. J. Bridgman has been occupied in an investigation of the age of plaice found in the western portion of the English Channel. The otoliths of a large number of fishes obtained from the neighbourhood of Plymouth and from the bays on the Devon coast to the east of Start Point have been examined for this purpose.

During the winter a Report on the Natural History of the American Slipper-Limpet (*Crepidula fornicata*) was prepared by Mr. J. H. Orton for the Kent and Essex Sea Fisheries Committee. In preparing this report it became evident that definite information as to the food of Crepidula would be valuable to the Kent and Essex oyster-farmers, whose oyster-beds are being overrun with this animal. A careful examination of the ingested food of the slipper-limpet was therefore undertaken, and a comparison made with the ingested food of oysters taken from the same grounds. This comparison established the curious fact that both kinds of animals were feeding on almost exactly the same food, that is, the various kinds of organisms found floating in the sea. After this conclusion had been arrived at, the way in which the slipper-limpet obtains its food was discovered. This observation confirmed the conclusion that the slipper-limpet feeds on the same food as the oyster, for it was found that it feeds in essentially the same way as the oyster, namely, by using its gill as a water-pump, and at the same time as a sieve for filtering the organisms from the water-current it produces. It was therefore made clear that the slipper-limpet is a keen competitor with the oyster for food and space.

This report was followed up by investigations leading to an explanation of the mechanism of the food-current in the slipper-limpet, the oyster, and other Gastropods and Lamellibranchs, and to slight additions to our knowledge of the mode of feeding in the Oyster, the Scallop, the Cockle, the Mussel, and some other bivalves.

Mr. Orton has also been occupied with general studies on the invertebrate fauna of the neighbourhood. A special feature of the collecting during the year has been the working of a fresh piece of rich shore collecting-ground immediately north of the Mewstone, where large gatherings of *Echinus miliaris*, *Cucumaria saxicola*, *Cucumaria normani*, and many other invertebrates have been made. Investigations are being made on the apparent pairing habits of *Echinus miliaris* and on the question of specific difference in the two species of Cucumaria mentioned above. A research on rate of growth in invertebrates has been begun by laying down marked bottles on the various grounds in Plymouth Sound. Useful material for this research was obtained last September from the floating raft moored in Cawsand Bay.

Mr. L. R. Crawshay has completed his report on the fauna of the deeper portion of the English Channel to the south-west of the Eddystone, a region which was practically unexplored previous to his investigations. This report is published in the Journal of the Association. In connection with the work, Dr. R. Hartmeyer, of Berlin, has described the ascidian fauna.

Messrs. Shearer, De Morgan, and Fuchs published a valuable paper on the hybridization of Echinoids in the Journal in October last, and they have since that time been continuing experimental work on the same subject.

Mr. G. H. Drew, who holds a Beit Memorial Fellowship for Medical Research, has worked at the Laboratory for the greater part of the year, and has continued to carry out experimental investigations on tissue growth, which bear directly on the cancer problem.

Mr. G. R. Mines, of the Cambridge Physiological Laboratory, assisted by Miss D. Dale, also of Cambridge, carried out at the Laboratory during last summer an important physiological investigation on the relations to electrolytes of the heart muscles of different species of skates and rays and of the mollusc, *Pecten maximus*. Mr. Mines's work showed what useful facilities the Laboratory can offer for physiological investigation, and it is the desire of the Council to do all in their power to encourage researches of this kind.

A fifth Blue Book has just been published by H.M. Stationery Office, containing the Fourth Report upon the work done by the Marine Biological Association in connection with the International Investigation of North Sea Fisheries. This report contains detailed memoirs on the experiments with marked plaice carried out in the North Sea, and on the transplantation of plaice from the inshore grounds to the Dogger Bank. The details of the trawling experiments made by the s.s. *Huxley* in the years 1906–9 are also recorded.

Published Memoirs.

The following papers, either wholly or in part the outcome of work done at the Laboratory, have been published elsewhere than in the official publications of the Association:—

Bloomer, H. H. *Anatomy of British Species of Psammobia.* Proc. Malac. Soc., vol. 9, 1911, pp. 231–9.

Drew, G. H. *A Note on some attempts to cause the Formation of Cytolysins and Precipitins in certain Invertebrates.* Journal of Hygiene, vol. 11, 1911, pp. 188–92.

Drew, G. H. *A Note on the Application of Giemsa's Romanowsky Stain to the Blood and Tissues of Marine Invertebrates.* Parasitology, vol. 4, 1911, pp. 19–21.

Lebour, M. V. *A Review of the British Marine Cercariae.* Parasitology, vol. 4, 1912, pp. 416–56.

MacBride, E. W. *Two Abnormal Plutei of Echinus, and the light which they throw on the Factors in the Normal Development of Echinus.* Quart. Journ. Micr. Sci., vol. 57, 1911, pp. 235–50.

Matthews, D. J. *Scottish Hydrographical Research.* Internat. Revue, Bd. 4, 1912, pp. 493–504.

Mines, G. R. *Note on the Mechanism of Discharge of the Cuvierian Organs of Holothuria nigra.* Quart. Journ. Micr. Sci., vol. 57, 1912, pp. 301–4.

Mines, G. R. *On the Relations to Electrolytes of the Hearts of Different Species of Animals. I. Elasmobranchs and Pecten.* Journal of Physiology, vol. 43, 1912, pp. 467–506.

Nicholls, G. E. *An Experimental Investigation on the Function of Reissner's Fibre.* Anat. Anzeiger, Bd. 40, 1912, pp. 409–32.

Orton, J. H. *An Account of the Natural History of the Slipper-Limpet (Crepidula fornicata), with some remarks on its occurrence on the Oyster Grounds on the Essex coast.* Printed by the Kent and Essex Sea Fisheries Committee, Jan. 1912, for distribution amongst the Committee.

Sexton, E. W. *On the Amphipod Genus Leptocheirus.* Proc. Zool. Soc., 1911, pp. 561–94.

Sexton, E. W. *A new Amphipod Species, Tryphosites alleni.* Ann. & Mag. Nat. Hist., ser. 8, vol. 7, 1911, pp. 510–13.

Shearer, C. *The Problem of Sex Determination in Dinophilus gyrociliatus.* Quart. Journ. Micr. Sci., vol. 57, 1912, pp. 329–71.

Smith, G. *Studies in the Experimental Analysis of Sex. VII. Sexual Changes in the Blood and Liver of Carcinus maenas.* Quart. Journ. Micr. Sci., vol. 57, 1911, pp. 251–65.

Taylor, T. H. *An Aid in the Study of Nematocysts.* Proc. Roy. Phys. Soc. Edin., vol. 18, 1912, pp. 235–40.

Woodland, W. N. F. *On some Experimental Tests of Recent Views concerning the Physiology of Gas Production in Teleostean Fishes.* Anat. Anzeiger, Bd. 40, 1911, pp. 225–42.

The Library.

The thanks of the Association are due for the following books and current numbers of periodicals presented to the Library during the past year:—

Académie Imp. des Sciences de St. Pétersbourg. Bulletin.
American Museum of Natural History. Annual Report.
American Microscopical Society. Transactions.
American Philosophical Society. Proceedings.
Armstrong College. Calendar.
Australian Museum. Memoirs.
—— Records.
—— Report.
Bergens Museum. Aarsberetning.
—— Aarbok.
—— An Account of the Crustacea of Norway, etc. By G. O. Sars.
Bermuda Biological Station for Research. Contributions.
Bernice Pauahi Bishop Museum, Honolulu. Fauna Hawaiiensis.
—— Memoirs.
—— Occasional Papers.
Board of Agriculture and Fisheries. Annual Report of Proceedings under the Salmon and Fresh-water Fisheries Acts.
—— Annual Report of Proceedings under Acts relating to Sea Fisheries.
—— Monthly Return of Sea Fisheries, England and Wales.
—— Report of Proceedings of Annual Meeting.
—— Report on the Research Work of the Board in relation to the Plaice Fisheries of the North Sea.
Bristol Naturalists' Society. Proceedings.
British Association for the Advancement of Science. Report.
British Museum. Catalogue of the Fresh-water Fishes of Africa in the British Museum.
Brown University. Contributions from the Biological Laboratory.
Bulletin Scientifique de la France et de la Belgique.

Bureau of the Productive Industries, Formosa. Icones Plantarum Formosanarum, nec non et Contributiones ad Floram Formosanam.
Bureau of Science, Philippine Islands. Journal of Science.
Cairo Zoological Gardens. Report.
Carnegie Institution of Washington: Dept. of Experimental Evolution. Annual Report of the Director.
—— Dept. of Marine Biology. Annual Report of the Director.
—— Papers from the Tortugas Laboratory.
—— On Germinal Transplantation in Vertebrates. By W. E. Castle and J. C. Phillips.
—— Experiments with *Drosophila ampelophila* concerning Evolution. By F. E. Lutz.
Ceylon Marine Biological Laboratory. Reports.
Club Montanyenc, Barcelona. Butlletí.
College of Science, Tokyo. Journal.
College voor de Zeevisscherijen. Verslag van den Staat der Nederlandsche Zeevisscherijen.
Colombo Museum. Director's Report.
—— Spolia Zeylanica.
R. Comitato Talassografico Italiano. Bollettino.
—— Memoria.
Comité du Laboratoire de Carlsberg. Comptes Rendus.
Conchological Society of Great Britain and Ireland. Journal of Conchology.
Conseil perm. internat. pour l'Exploration de la Mer. Bulletin Trimestriel des Résultats acquis pendant les Croisières Périodiques.
—— Publications de Circonstance.
—— Bulletin Hydrographique.
—— Bulletin Statistique.
Cornwall Sea Fisheries Committee. Reports.
Danish Biological Station. Report.
Dept. of Agriculture, etc., Ireland. Report.
—— Scientific Investigations.
Dept. of Commerce and Labor, Bureau of Fisheries, U.S.A. Pamphlets.
—— Report of the Commissioner of Fisheries.
—— Reports in relation to the Condition of Seal Life on the Rookeries of the Pribilof Islands, and to Pelagic Sealing in Bering Sea and the North Pacific Ocean in the years 1893–5. With Atlas.
Dept. of Fisheries, New South Wales. Annual Report.
—— On the Need for more Uniformity in the Vernacular Names of Australian Edible Fishes. By D. G. Stead.
—— The Future of Commercial Marine Fishing in New South Wales. By D. G. Stead.
Dept. of Marine and Fisheries, Canada. Annual Report.
Dept. of Trade and Customs, Melbourne. *Onchocerca gibsoni:* The cause of Worm Nodules in Australian Cattle. With Notes on Worm Nests in Australian Cattle and in Camels. By J. B. Cleland and T. H. Johnston.
—— Zoological Results of the Fishing Experiments carried out by the F.I.S *Endeavour* 1909–10.
Deutschen Fischerei-Vereins. Zeitschrift für Fischerei.
Deutscher Seefischerei-Verein. Mitteilungen.

Dominion Museum. Bulletin.
Durban Museum, Natal. Report.
La Feuille des Jeunes Naturalistes.
Field Museum of Natural History. Report.
Finnländische Hydrographisch-Biologische Untersuchungen. Abhandlungen.
Fisheries Society of Japan. Journal.
The Fisherman's Nautical Almanac. By O. T. Olsen.
Fishery Board of Scotland. Annual Report.
—— Scientific Investigations.
Fiskeri-Beretning.
Government of Bombay. The Present Depletion of the Oyster Bed of Sind; its Causes and the Remedies. By J. Hornell.
Government Museum, Madras. Report.
Illinois State Laboratory of Natural History. Bulletin.
Imperial Cancer Research Fund. Report.
Indian Museum. Memoirs.
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Institut Océanographique. Annales.
R. Irish Academy. Proceedings.
Kommission zur wissenschaftlichen Untersuchung der Deutschen Meere, etc. Wissenschaftliche Meeresuntersuchungen.
Kommissionen for Havundersögelser, Copenhagen. Meddelelser.
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K. Bayerischen Akademie der Wissenschaften, München. Abhandlungen.
—— Sitzungsberichte.
Kgl. Danske Videnskabernes Selskab. Oversigt.
—— Skrifter.
K. Fysiografiska Sällskapets i Lund. Handlingar.
Kgl. Norske Videnskabernes Selskab. Skrifter.
Laboratoire Biologique de St. Pétersbourg. Bulletin.
Lancashire and Western Sea Fisheries. Superintendent's Report.
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Linnean Society. Journal.
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Marine Biological Laboratory, Woods Holl. Biological Bulletin.
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—— Annual Report of the Committee.
R. Microscopical Society. Journal.
Musée Océanographique de Monaco. Bulletin.

Museo de La Plata. Catálogo de la Seccion Antropológica.
—— Revista.
Museo Nacional, Buenos Aires. Anales.
Museo Nacional de Chile. Boletin.
Museum of Comparative Zoology, Harvard College. Bulletin.
—— Memoirs.
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Muséum National d'Histoire Naturelle, Paris. Bulletin.
The Museums Journal.
Natal Scientific Society. Transactions and Proceedings.
Natural History Society of New Brunswick. Bulletin.
Natural History Transactions of Northumberland, Durham, and Newcastle-on-Tyne.
Naturforschende Gessellschaft in Basel. Verhandlungen.
Naturhistorischen Museum, Hamburg. Mitteilungen.
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New York Academy of Sciences. Annals.
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La Nuova Notarisia.
Oberlin College. The Wilson Bulletin.
Owens College, Manchester. Intensive Study of the Scales of Three Specimens of *Salmo salar*. By P. C. Esdaille.
—— The Alcyonaria of the Cape of Good Hope and Natal. Gorgonacea. By J. S. Thomson.
—— Some Madreporaria from the Persian Gulf. By R. Harrison. With a Note on the Memoir and some Further Notes on *Pyrophyllia inflata* by S. J. Hickson.
Oxford University Museum. Catalogue of Books added to the Radcliffe Library.
Physiographiske Forening, Christiania. Nyt Magazin for Naturvidenskaberne.
Plymouth Institution. Report and Transactions.
Quarterly Journal of Microscopical Science. (Presented by Sir E. Ray Lankester, K.C.B., F.R.S.)
Queensland Museum. Annals.
Rijksinstituut voor het Onderzoek der Zee. Helder. Jaarboek.
—— Verhandelingen.
Royal Commission on Sewage Disposal. Reports.
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Scottish Oceanographical Laboratory. Report of the Scientific Results of the Voyage of S.Y. *Scotia*.
Selskabet for de Norske Fiskeriers Fremme. Norsk Fiskeritidende.
Senckenbergische naturforschende Gesellschaft, Frankfurt. Bericht.

Smithsonian Institution. Opinions rendered by the International Commission on Zoological Nomenclature.

Sociedad Geográfica de Lima. Boletin.

Sociedad Scientifica de São Paulo. Revista.

Societas pro Fauna et Flora Fennica. Acta.

—— Meddelanden.

Société Belge de Géologie, etc. Bulletin.

—— Nouveaux Mémoires.

Société Centrale d'Aquiculture et de Pêche. Bulletin.

Société de Géographie de Finlande. Atlas de Finlande.

Société d'Océanographie du Golfe de Gascogne. Mission Arctique commandée par M. Charles Bénard. VI. Stations Scientifiques. Cartographie Météorologie.

—— Le Sauvetage Maritime. By E. Debrosse.

Société Imp. Russe de Pisciculture et de Pêche. Vyestnīk R'ibopom'shlennostī.

Société Zoologique de France. Bulletin.

—— Mémoires.

South African Museum. Annals.

Station Aquicole de Boulogne-sur-Mer. Annales.

Kgl. Svenska Vetenskaps-Akademien. Arkiv för Botanik.

—— Arkiv för Zoologie.

—— Handlingar.

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—— New Genera of Starfishes from the Philippine Islands. By W. K. Fisher.

—— Fresh-Water Sponges in the Collection of the United States National Museum. Part V. A New Genus proposed, with *Heteromeyenia radiospiculata* Mills as Type. By N. Annandale.

—— Description of a New Species of Ægà from the Atlantic Coast of the United States. By H. Richardson.

—— Description of a new Genus and Species of Janiridae from the North-West Pacific. By H. Richardson.

—— A New Unstalked Crinoid from the Philippine Islands. By A. H. Clark.

—— Description of Recently Discovered Cladocera from New England. By A. A. Doolittle.

—— Description of a New Isopod Crustacean belonging to the Genus Livoneca from the Atlantic Coast of Panama. By H. Richardson.

—— Instructions for Collecting and Fixing Rotifers in Bulk. By P. de Beauchamp.

—— Naumachocrinus, a New Genus belonging to the Crinoid Family Phrynocrinidae. By A. H. Clark.

—— Description of a New Species of Isopod of the Genus Cleantis from Japan. By H. Richardson.

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—— The Crustacea of the Order Cumacea in the Collection of the United States National Museum. By W. T. Calman.

—— Marine and Terrestrial Isopods from Jamaica. By H. Richardson.

—— Descriptions of New Species of Parasitic Copepods in the Collections of the United States National Museum. By C. B. Wilson.

—— Notes on Fresh-Water Copepoda in the United States National Museum. By C. D. Marsh.

—— New Arenaceous Foraminifera from the Philippine Islands and Contiguous Waters. By J. A. Cushman.

University of California. Publications. Zoology, Physiology, Botany.

University of Pennsylvania. Contributions from the Botanical Laboratory.

—— Contributions from the Zoological Laboratory.

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Kgl. Vetenskaps Societeten, Upsala. Nova Acta.

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—— Mitteilungen.

Mr. F. J. Bridgman. First Principles. By H. Spencer.

Prof. Chas. Chilton. Index Faunae Novae Zealandiae. By F. W. Hutton.

The Director, The Royal Gardens, Kew. On the Growth of *Ulva latissima* in excessive quantity, with Special Reference to the Ulva-Nuisance in Belfast Lough. Botanical Report. By A. D. Cotton.

Dr. G. H. Fowler. On the Annual Range of Temperature in the Surface Waters of the Ocean, and its relation to other Oceanographical Phenomena. By Sir John Murray.

—— Studies on the Nuclear Cycle of *Gonionemus murbachii* A. G. Mayer. By H. B. Bigelow.

—— Ostracoda of the San Diego Region. I. II. By C. Juday.

—— Cladocera of the San Diego Region. By C. Juday.

—— The Siphonophora of the *Siboga* Expedition. By A. D. Lens and T. van Riemsdijk.

Prof. J. Stanley Gardiner. *Paraceratherium bugtiense*, a New Genus of Rhinocerotidae from the Bugti Hills of Baluchistan. By C. Forster-Cooper.

—— Cytological Observations on Cross-Fertilized Echinoderm Eggs. By L Doncaster and J. Gray.

—— The Behaviour of the Infusorian Micronucleus in Regeneration. By K. R. Lewin.

—— Note on the Inheritance of Characters in which Dominance appears to be influenced by Sex. By L. Doncaster.

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—— A Revision of the British Leeches. By W. A. Harding.
—— Percy Sladen Trust Expedition to the Indian Ocean in 1905. Description of the Expedition (concluded), with Observations for Terrestrial Magnetism and some Account of Bird and Dennis Islands. By J. S. Gardiner, B. T. Somerville, and J. C. F. Fryer.
—— The Structure and Formation of Aldabra and Neighbouring Islands, with Notes on their Flora and Fauna. By J. C. F. Fryer.
Dr. P. P. C. Hoek. Verslag van den Staat der Nederlandsche Zeevisscherijen over 1910.
—— Rapport over Schelpdierenvisscherij en Schelpdierenteelt in de Noordelijke Zuiderzee.
Prof. E. L. Mark. A Comparison of the Reactions of a Species of Surface Isopod with those of a Subterranean Species. By A. M. Banta.
—— The Reactions of Amphibians to Monochromatic Lights of Equal Intensity. By H. Laurens.
—— Contributions to the Physiology of Regeneration. IV. By S. Morgulis.
—— Studies on Early Stages of Development in Rats and Mice. III. The Living Eggs of Rats and Mice, with a Description of Apparatus for Obtaining and Observing them. By J. A. Long.
Dr. C. Shearer. Description of an Apparatus for Recording the Activity of Small Mammals. By J. R. Slonaker.
—— The Normal Activity of the Albino Rat from Birth to Natural Death, its Rate of Growth and the Duration of Life. By J. R. Slonaker.
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To the authors of the Memoirs mentioned below the thanks of the Association are due for separate copies of their works presented to the Library:—

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Arwidsson, I. Die Maldaniden.
—— Some Irish Maldanidae.
—— Beiträge zur Kenntnis der Unterfamilie Maldaninae.
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Ashworth, J. H. Observations on the Structure and Affinities of *Branchiomaldane vincenti* Langerhans.
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—— Scientific Results of the New Zealand Government Trawling Expedition, 1907.
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—— Note on the Dispersal of Marine Crustacea by means of Ships.
—— Revision of the New Zealand Stomatopoda.
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Cligny, A. Migration marine de l'anguille commune.
Cotton, A. D. *Lithophyllum* in the British Isles.
—— On the Increase of *Colpomenia sinuosa* in Britain.
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Dakin, W. J. Notes on a New Coccidian (*Merocystis kathae* n. gen. et sp.) occurring in the Renal Organ of the Whelk.
—— Notes on the Biology of Fish Eggs and Larvae.
Davenport, C. B. The Biological Laboratory at Cold Spring Harbor, New York, U.S.A.
Downing, E. R. The Formation of the Spermatophore in Arenicola and a Theory of the Alternation of Generations in Animals.
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—— Experimental Metaplasia I. The Formation of Columnar Ciliated Epithelium from Fibroblasts in Pecten.
—— A Note on some Attempts to cause the Formation of Cytolysins and Precipitins in certain Invertebrates.
—— A Table showing certain Cultural Characteristics of some of the commonest Bacteria found in the Laboratory Tanks at Plymouth.
—— The Action of some Denitrifying Bacteria in Tropical and Temperate Seas, and the Bacterial Precipitation of Calcium Carbonate in the Sea.
Dunkerly, J. S. On the Occurrence of Thelohania and Prowazekia in Anthomyid Flies.
—— On some Stages in the Life-History of *Leptomonas muscae domesticae*. With some Remarks on the Relationships of the Flagellate Parasites of Insects.
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—— Enchytraeids of the North of England.
Gamble, F. W., and Drew, G. H. Note on Abnormal Pigmentation of a Whiting infected by Trematode Larvae.
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—— Zur Anatomie und Entwicklungsgeschichte der *Argyroneta aquatica* Cl.

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Hasper, M. Zur Entwicklung der Geschlechtsorgane von *Chironomus*.

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—— Colour in Animals.

—— The Saw-Fly Pest in the Lake District.

—— On a Specimen of *Osteocella septentrionalis* (Gray).

—— On *Polytrema* and some Allied Genera. A Study of some Sedentary Foraminifera based mainly on a Collection made by Prof. Stanley Gardiner in the Indian Ocean.

Hoek, P. P. C. Les Clupéides (le Hareng excepté) et leurs migrations.

Horst, R. On the Synonymy of *Pherecardia lobata* Horst.

Innes, A. G. Tidal Action in the Bure and its Tributaries.

Jameson, H. L. An Examination of the Causes which have led to the Failure of the Biological Work recently undertaken on the Ceylon Pearl Fisheries.

Janet, C. Organes sensitifs de la mandibule de l'Abeille (Apis mellifera L. ♀).

—— Note sur la Phylogénese de l'Insecte.

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—— Prehistoric Fishing in Japan.

Klinghardt, F. Über die innere Organisation und Stammesgeschichte einiger irregulärer Seeigel der oberen Kreide.

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Legendre, R. La Pêche chez les peuples primitifs.

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Lohmann, H. Untersuchungen über das Pflanzen- und Tierleben der Hochsee im Atlantischen Ozean während der Ausreise der *Deutschland.*

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—— Sur deux espèces et une variété nouvelles du Genre Palaemon Fabr. provenant du Congo Belge.

Mangan, J. The Occurrence of *Necrobia* and *Dermestes* in Cotton Bales.

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—— Ctenophores of the Atlantic Coast of North America.

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—— On the Relations to Electrolytes of the Hearts of Different Species of Animals. I. Elasmobranchs and Pecten.

Murie, J. "Slipper-Limpet" or "Boat-Shell" (*Crepidula fornicata*): its Introduction and Influence on Kent and Essex Oyster-Beds.

Nicholls, G. E. An Experimental Investigation on the Function of Reissner's Fibre.

Okamura, K. Some Littoral Diatoms of Japan.

Orton, J. H. An Account of the Natural History of the Slipper-Limpet (*Crepidula fornicata*), with some Remarks on its Occurrence on the Oyster-Grounds on the Essex Coast.

Paulsen, O. The Plankton on a Submarine Bank.

Pettersson, O. Studien über die Bewegungen des Tiefenwassers und ihren Einfluss auf die Wanderung der Heringe.

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—— Vorlaüfige mitteilung über neue Fische von Lombok.

—— Ichthyographische Übersicht von Lombok.

—— La fonction de la Vessie aèrienne des Poissons.

Ritchie, J. New Species and Varieties of Hydroida thecata from the Andaman Islands.

—— Note on a Rare Plumularian Hydroid, *Cladocarpus formosus.*

—— Is the Hydroid, *Selaginopsis mirabilis,* a Native of British Seas?

—— Contribution to our knowledge of the Hydroid Fauna of the West of Scotland. Being an Account of Collections made by Sir John Murray, K.C.B., on S.Y. *Medusa.*

—— Two Unrecorded *Challenger* Hydroids from the Bermudas, with a note on the Synonymy of *Campanularia insignis.*

—— An Ambicolored Turbot with Eyes Approximately Normal in Position.

—— A Hump-backed Trout from Stranraer.

—— On the Distribution of the Thorny Lobster (*Palinurus vulgaris*) in British Waters.

—— On an Entoproctan Polyzoon (*Barentsia benedeni*) new to the British Fauna, with Remarks on Related Species.

—— Supplementary Report on the Hydroids of the Scottish National Antarctic Expedition.

Ritchie, J., and McIntosh, D. C. On a Case of Imperfect Development in *Echinus esculentus.*

Schaxel, J. Das Verhalten des Chromatins bei der Eibildung einiger Hydrozoen.

Schaxel, J. Plasmastrukturen, Chondriosomen und Chromidien.

—— Die Oogenese von *Pelagia noctiluca* Pér. et Less. mit besonderer Berücksichtigung der Chromidien und Nucleolen.

—— Die Morphologie des Eiwachstums und der Follikelbildungen bei den Ascidien. Ein Beitrag zur Frage der Chromidien bei Metazoen.

—— Die Bedeutung des Chromatins nach Untersuchungen an Metazoenzellen.

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—— Phytoplankton von Westindien.

Sexton, E. W. A New Amphipod Species, *Tryphosites alleni.*

—— On the Amphipod Genus Leptocheirus.

—— The Amphipoda collected by the *Huxley* from the North Side of the Bay of Biscay in August, 1906.

Shearer, C., De Morgan, W., and Fuchs, H. M. Preliminary Notice on the Experimental Hybridization of Echinoids.

Shipley, A. E. Strongylosis in the Sheep.

—— The Diseases of Hive-Bees.

Southwell, T. The Pearl-Inducing Worm.

Stebbing, T. R. R., and Herdman, W. A. The Terms Polyzoa and Bryozoa.

Tait, J. A Simple Method of Observing the Agglutination of the Blood Corpuscles in Gammarus.

—— Crustacean Blood Coagulation as Studied in the Arthrostraca.

—— Colour Change in the Isopod *Ligia oceanica.*

—— Blood Coagulation in the Amphipod, Gammarus.

Taylor, T. H. An Aid in the Study of Nematocysts.

Vayssière, A. Sur les Opisthobranches et sur les Marséniadés du golfe de Tadjourah.

Walker, A. O. On *Gammarus campylops* Leach.

—— Notes on *Jassa falcata.*

Woodcock, R. Colour Varieties of *Donax variegatus* (Gmelin) from the Channel Islands.

Woodland, W. N. F. On some Experimental Tests of Recent Views concerning the Physiology of Gas Production in Teleostean Fishes.

Donations and Receipts.

The receipts for the year include the grants from His Majesty's Treasury (£1000) and the Worshipful Company of Fishmongers (£400), Special Donations (£204), Annual Subscriptions (£149), Rent of Tables in the Laboratory (£71), Sale of Specimens (£478), Admission to Tank Room (£94).

The following is a list of the Special Donations :—

	£	s.	d.
G. P. Bidder, Esq. . . .	100	0	0
H. Swithinbank, Esq. . . .	100	0	0
Dr. Edgar Schuster . . .	4	4	0
G. H. Fox, Esq.		10	6
	£204	14	6

Vice-Presidents, Officers, and Council.

The following is the list of gentlemen proposed by the Council for election for the year 1912–13:—

President.

Sir E. Ray Lankester, K.C.B., LL.D., F.R.S.

Vice-Presidents.

The Duke of Abercorn, K.G., C.B.
The Duke of Bedford, K.G.
The Earl of Ducie, F.R.S.
The Earl of Stradbroke, C.V.O., C.B.
Lord Avebury, F.R.S.
Lord Walsingham, F.R.S.
The Right Hon. A. J. Balfour, M.P., F.R.S.
The Right Hon. Joseph Chamberlain, M.P.
The Right Hon. Austen Chamberlain, M.P.
W. Astor, Esq., M.P.
G. A. Boulenger, Esq., F.R.S.
A. C. L. Günther, Esq., F.R.S.
A. R. Steel-Maitland, Esq., M.P.
Sir John Murray, K.C.B., F.R.S.
Rev. Canon Norman, D.C.L., F.R.S.
Edwin Waterhouse, Esq.

Members of Council.

W. T. Calman, Esq., D.Sc.
Prof. A. Dendy, D.Sc., F.R.S.
G. H. Drew, Esq.
Prof. F. W. Gamble, D.Sc., F.R.S.
Sir Eustace Gurney.
Commander M. W. Campbell Hepworth, C.B., R.N.R.
Prof. J. P. Hill, D.Sc.
E. W. L. Holt, Esq.
Prof. E. W. MacBride, D.Sc., F.R.S.
P. Chalmers Mitchell, Esq., D.Sc., F.R.S.
Edgar Schuster, Esq., D.Sc.
Geoffrey W. Smith, Esq.
Prof. D'Arcy W. Thompson, C.B.

Chairman of Council.

A. E. Shipley, Esq., D.Sc., F.R.S.

Hon. Treasurer.

J. A. Travers, Esq., Tortington, Arundel.

Hon. Secretary.

E. J. Allen, Esq., D.Sc., The Laboratory, Citadel Hill, Plymouth.

The following Governors are also members of the Council:—

G. P. Bidder, Esq., M.A.
The Earl of Portsmouth (Prime Warden of the Fishmongers' Company).
Sir Richard Martin, Bart. (Fishmongers' Company).
The Hon. Nathaniel Charles Rothschild (Fishmongers' Co.).
Prof. G. C. Bourne, D.Sc., F.R.S. (Oxford University).
A. E. Shipley, Esq., D.Sc., F.R.S. (Cambridge University).
Prof. W. A. Herdman, D.Sc., F.R.S. (British Association).

Dr. *Statement of Receipts and Payments for*

		£ s. d.	£ s. d.
To Balance from last year :—			
Cash at Bank		316 0 4	
Cash in hand		6 14 9	
		322 15 1	
Less Bank Loan		300 0 0	22 15 1
,, Current Income :—			
H.M. Treasury		1,000 0 0	
The Worshipful Company of Fishmongers, including £200 on account of 1912–13		600 0 0	
Annual Subscriptions		146 4 0	
Composition Fee		15 15 0	
Rent of Tables, including £20 from the Trustees of the Ray Lankester Fund		71 19 6	1,833 18 6
,, Extraordinary Receipts :—			
Donations, per Report			204 14 6
,, Balance :—			
Loan from Bank		400 0 0	
Overdraft at Bank		63 1 0	
		463 1 0	
Less Cash at Bank	120 10 8		
Cash in hand	0 1 2	120 11 10	342 9 2
Amount overdrawn on General Account		542 9 2	
Less Repairs and Renewals		200 0 0	
		£342 9 2	
			£2,403 17 3

Examined and found correct.

(Signed) N. E. Waterhouse.
Wyndham Birch.
L. W. Byrne.
W. T. Calman.

3 Frederick's Place,
Old Jewry, E.C.
26*th June*, 1912.

the Year ending 31st May, 1912.

Cr.

		£ s. d.	£ s. d.
By Current Expenditure :—			
Salaries and Wages—			
Director		200 0 0	
Hydrographer		150 0 0	
Naturalist		250 0 0	
Additional Naturalist		133 6 8	
Assistant Naturalist		150 0 0	
Salaries and Wages, and Compensation paid		716 12 2	
		1,599 18 10	
Less Compensation recovered from Employers' Liability Assurance Corporation		40 1 8	1,559 17 2
Travelling Expenses			45 12 2
Library		122 9 3	
Less Duplicates sold		3 4 9	119 4 6
Lecture Expenses			31 11 11
Journal		62 1 9	
Less Sales		14 6 0	47 15 9
Buildings and Public Tank Room—			
Gas, Water, and Coal		118 7 11	
Stocking Tanks and Feeding		32 15 1	
Maintenance and Renewals		94 18 5	
Rent, Rates, Taxes, and Insurance		70 4 8	
		316 6 1	
Less Admission to Tank Room		94 1 6	222 4 7
Laboratory, Boats, and Sundry Expenses—			
Glass, Apparatus, and Chemicals		212 9 5	
Less Sales		35 13 1	
		176 16 4	
Purchase of Specimens		66 11 6	
Maintenance and Renewal of Boats, Nets, Gear, etc.	359 15 5		
Less Sales	21 18 11	337 16 6	
Insurance of s.y. *Oithona*		18 17 7	
Coal and Water for Steamer		106 18 3	
Stationery, Office Expenses, Printing, etc.		146 16 6	
		853 16 8	
Less Sale of Specimens		477 19 1	375 17 7
By Bank Interest			1 13 7
			£2,403 17 3

Walter Ibbotson Beaumont.

Many workers at the Plymouth Laboratory will have heard with deep regret of the death of Mr. Beaumont, who was accidentally drowned whilst yachting at Tarbert, Loch Fyne, on May 3rd, 1912. Mr. Beaumont first came to Plymouth in 1895, and from that time he spent several months of each year at the Laboratory. He had commenced the study of biology under the late Professor Milnes Marshall, in Manchester, and subsequently went to Cambridge, where he entered Emmanuel College. He was chiefly interested in faunistic work, and contributed valuable papers on nemerteans, schizopods, and nudibranchs from Port Erin, Plymouth, and Valencia. He was also a keen student of bird-life, and did much useful work in connection with bird-marking and bird migration.

George Herbert Grosvenor.

Mr. Grosvenor will always be remembered by a large number of younger English biologists from the fact that for a number of years he conducted the annual Easter Vacation Course in Marine Biology at the Plymouth Laboratory, and it was under his guidance that they obtained their first acquaintance with the wealth of living creatures that are found in the sea. He was a man of a singularly cheerful and attractive disposition, a keen observer, and an enthusiastic naturalist. His principal contribution to marine biology was the paper in which he demonstrated that the nematocysts of nudibranchs are derived from the hydroids upon which they feed. Latterly Mr. Grosvenor worked chiefly at agricultural entomology in connection with his post of lecturer in that subject at Oxford. Mr. Grosvenor was drowned whilst bathing at Polzeath, in Cornwall, on September 4th, 1912, in an attempt to help a companion who was in difficulties.

George Harold Drew.

The sudden death of Mr. Drew, at Plymouth, on January 30th, 1913, at the age of thirty, came as a great shock both to his fellow-workers at the Laboratory and to his many friends elsewhere. Since leaving Cambridge as an undergraduate he had spent most of his time in Plymouth, and the originality and successful character of his work had marked him out as one of the most promising of the younger English biologists. His experimental work on tissue growth, which he undertook in connection with the study of cancer, yielded results which are bound to have much influence on future researches on this subject. In addition to his pathological investigations, Mr. Drew made a special study of marine bacteria and of the general problems of the metabolism of the sea. In connection with this work he made expeditions to the West Indies in 1911 and 1912, and some results of his observations are published in the paper which appears in the present number of this journal, the final proofs of which he had corrected shortly before his death. He was a man of much originality of mind and independence of character, and possessed a charm of personality which made his friendship peculiarly attractive.

E. J. A.

BY-LAWS

MEMBERS.

1. The Association shall consist of Governors, Founders, Life Members, and Annual Members, from whom shall be chosen the Council, Officers, and not more than twenty Vice-Presidents.

2. A number of Associate Members, not exceeding fifty in all, may be elected from among persons connected with Marine Fisheries or interested in Marine Botany or Zoology.

COUNCIL.

3. The affairs of the Association shall be conducted and its laboratories managed by a Council consisting of the Governors, the Officers, the Prime Warden of the Fishmongers' Company for the time being, and fourteen other Members to be chosen annually who shall be eligible for re-election, except that the two senior elected Members of Council according to date of election shall retire each year, and shall not be eligible for re-election until they have been out of office one year. In case of equal seniority the order of retirement shall be determined by lot. None of the above provisions as to retirement shall apply to any one member or officer of each of the three following Government Departments, namely, the Board of Agriculture and Fisheries, the Scottish Fishery Board, and the Board of Agriculture and Technical Instruction for Ireland, whom being a member of Council the Association may desire to re-elect as the representative of his Department on the Council. At Meetings of the Council five shall be a quorum.

4. The Council shall have power to appoint from time to time from among their number such Committees as the Council may deem expedient, and may delegate to such Com-

mittees such of the powers of the Council (including power to affix the Seal to documents relating to matters referred to or dealt with by such Committees) as the Council may determine. When executive functions are exercised by such Committees three shall be a quorum. Such Committees shall periodically report their proceedings to the Council, and shall conduct their proceedings in accordance with the directions of the Council.

OFFICERS.

5. The Officers of the Association shall consist of a President, a Chairman of Council (who shall be *ex-officio* a Vice-President), an Honorary Treasurer, and an Honorary Secretary, all of whom shall be chosen annually from amongst the Members, but shall be eligible for re-election.

6. In the event of any vacancy occurring in the Council, or among the Officers or Vice-Presidents, the Council at their next or any later Meeting after such vacancy has been made known, shall elect some duly qualified person to the vacant office.

7. The President shall preside at the Meetings of the Association, and shall regulate the discussions and proceedings thereat.

8. In the absence of the President at any meeting of the Association, a Vice-President shall preside; and, in the absence of all the Vice-Presidents, a Member of the Council shall preside; and, if no Member of the Council be present at any Ordinary Meeting, the Members present shall appoint such Member as they shall think fit to be Chairman.

9. The Chairman of Council shall preside at the Meetings of the Council, and shall regulate the discussions and proceedings thereat. In his absence, the Members of the Council present shall appoint such Member of the Council as they think fit to act as his deputy.

10. In case of an equality of votes at meetings of the Association, or of the Council, the Member presiding shall have a second or casting vote.

11. It shall be the duty of the Hon. Treasurer to receive all sums of money due to the Association, and to disburse all sums payable by the Association out of the funds in his hands.

12. No payment exceeding £15 (except for rent, taxes, or wages) shall be made by the Hon. Treasurer without the consent of the Council.

13. The Accounts of the Hon. Treasurer shall be audited previous to each Annual Meeting by a Committee of two Members of the Council and two Members of the Association, to be appointed by the Council, of which Committee three shall be a quorum.

DIRECTOR.

14. A Director of the Laboratory, who shall also act as Assistant Secretary of the Association, shall be elected by the Council, and shall be paid such a salary as shall from time to time be determined.

15. It shall be the duty of the Director to maintain the laboratories, aquarium and library, and other property of the Association, in a state of efficiency; to superintend and direct the scientific work at the laboratories; to prepare and edit the publications of the Association; to keep a list of all the Members of the Association, together with their addresses; to summon Meetings of the Association and of the Council; to conduct all correspondence; to take minutes of the proceedings of the Association and the Council, and generally to act under the direction of the Council in all matters connected with the affairs of the Association.

16. The Council may employ an Assistant to the Director, who shall receive such remuneration and shall be subject to such directions as they shall from time to time determine.

ELECTION, WITHDRAWAL, REMOVAL, AND PRIVILEGES OF MEMBERS.

17. Every candidate for election as a Member or Associate Member shall be proposed in writing by a Member, and such proposal shall be forwarded to the Director, who shall lay it before the Council at the next succeeding Meeting.

18. The method of voting for the election of Members shall be by ballot, and a majority of the Council balloting shall elect.

19. The payments to be made by the Members shall be as follows:—A Governor shall pay £500, and a Founder shall pay £100. An Ordinary Member shall pay £1 1s. annually. The annual contribution may be compounded for at any time on payment of £15 15s. Any University of the United Kingdom or other Corporation or body approved by the Council, on the payment of £500 to the Association in the name of the University or other Corporation or body, and for the purpose of acquiring the right herein specified, shall, if the Council of the Association assent thereto, become a Governor of the Association and acquire the perpetual right of nominating annually one Member of the Council of the Association to serve for one year (from the Annual Meeting in one year to that in the following year), and any Member of the University, Corporation or body subscribing £100 or more to such fund of £500, shall, in virtue of such subscription, become a "Founder" of the Association.

20. The annual contribution shall become due on the 1st January in advance; but any Member elected in the months of October to December inclusive, and paying a contribution during that period, will not be called upon for a second contribution for the year following his election.

21. Every Member having paid all sums due to the Association shall be at liberty to withdraw therefrom, upon giving notice in writing to the Director.

22. Whenever written notice of a motion for removing any Member shall be delivered to the Director, signed by the President or Chairman for the time being on the part of the Council, or by five or more Members, such notice shall be sent by post to each Member seven days before the next Annual or Special Meeting of the Association, when such motion shall be taken into consideration and decided by ballot. If a majority of the Members balloting shall vote that such Member be removed, he shall be removed from the Association accordingly.

23. Whenever any Member shall be in arrear for two years in the payment of his annual contribution, notice thereof in writing shall be sent to him by the Hon. Treasurer, and in case the contribution shall remain unpaid, the Hon. Treasurer shall give notice thereof to the Council, who shall cause a similar notice to be sent to the Member with an intimation that at the expiration of three months he will be liable to have his name erased from the list of Members. In default of payment the Council may order his name to be erased accordingly.

24. Members shall have the right to be present, to state their opinions, and to vote at all Meetings of the Association; to propose candidates for admission as Members; to introduce visitors at Meetings of the Association; to have personal access and to introduce strangers to the laboratories, and to make use of the library, subject to such regulations as the Council may from time to time prescribe.

25. Members shall be eligible to any office in the Association, provided they are not more than one year in arrear in the payment of the annual contribution.

26. A Member shall not be entitled to vote on any occasion until he shall have paid his contribution for the year last past.

ASSOCIATE MEMBERS.

27. Associate Members shall not be required to pay any contribution to the funds of the Association, but are expected to communicate information to the Association on Marine Fisheries and on Marine Zoology or Botany, to supply specimens, and to advance the objects of the Association in other ways.

28. Associate Members shall not be eligible to any office in the Association, nor shall they be entitled to vote at any Meeting.

29. Associate Members shall have personal access to the laboratories and library of the Association, subject to the regulations of the Council in force for the time being.

ANNUAL MEETING.

30. The Annual Meeting of the Association shall be held in April in each year on such day and at such time as the Council shall from time to time direct.

31. The object of the Meeting shall be to receive from the Council their annual report on the affairs of the Association, and to elect the Council, Officers, and Vice-Presidents for the ensuing year.

32. The Council shall cause to be prepared a list containing the names of Members whom they shall recommend to be elected as the Council, Officers, and Vice-Presidents, for the year ensuing, and a copy of such list shall be hung up in the Office of the Association not later than the 15th March.

33. If any five or more Members shall desire to substitute for any of the names in the said list, the names or name of any other Member or Members, they shall give notice in writing to that effect, specifying the names or name proposed to be substituted; such notice to be given on or before the 31st March to the Director, who shall cause the same to be forthwith hung up in the Office of the Association.

34. If no such notice is given to the Director, the Members named in the list prepared by the Council shall be held to be elected as the Council, Officers, and Vice-Presidents for the ensuing year.

35. If any such notice is given, the election shall be by ballot at the Annual Meeting, and the President or Chairman shall appoint two or more Scrutineers from the Members present, not being Members of the Council, to superintend the ballot, and to report the result to the Meeting.

36. Any balloting list containing a greater number of names proposed for any office than the number to be elected to such office shall be rejected by the Scrutineers.

37. No ballot shall be taken unless five or more Members vote.

SPECIAL MEETINGS.

38. The Council may at any time convene a Special Meeting of the Association, and shall do so upon the requisition of any twenty or more Members presented to the Council. A notice thereof shall be sent to every Member whose last known residence was in the United Kingdom, seven clear days before such Meeting shall take place, and the general nature of any proposition to be submitted to such Meeting shall be stated in the notice.

39. No vote shall be taken at any Special Meeting, unless twenty or more Members shall be present in person or by proxy. Members absent from the Meeting may vote either by proxy, or by previously sending their votes in writing to the Director.

40. Any of the By-Laws of the Association may be repealed or altered or others adopted in lieu thereof at an Annual or Special Meeting, but no resolution for effecting any such repeal or alteration shall be proposed at any Annual Meeting unless at least fourteen days' notice in writing specifying the terms of such resolution shall have been given to the Director, or unless it has received the sanction of the Council.

June, 1912.

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